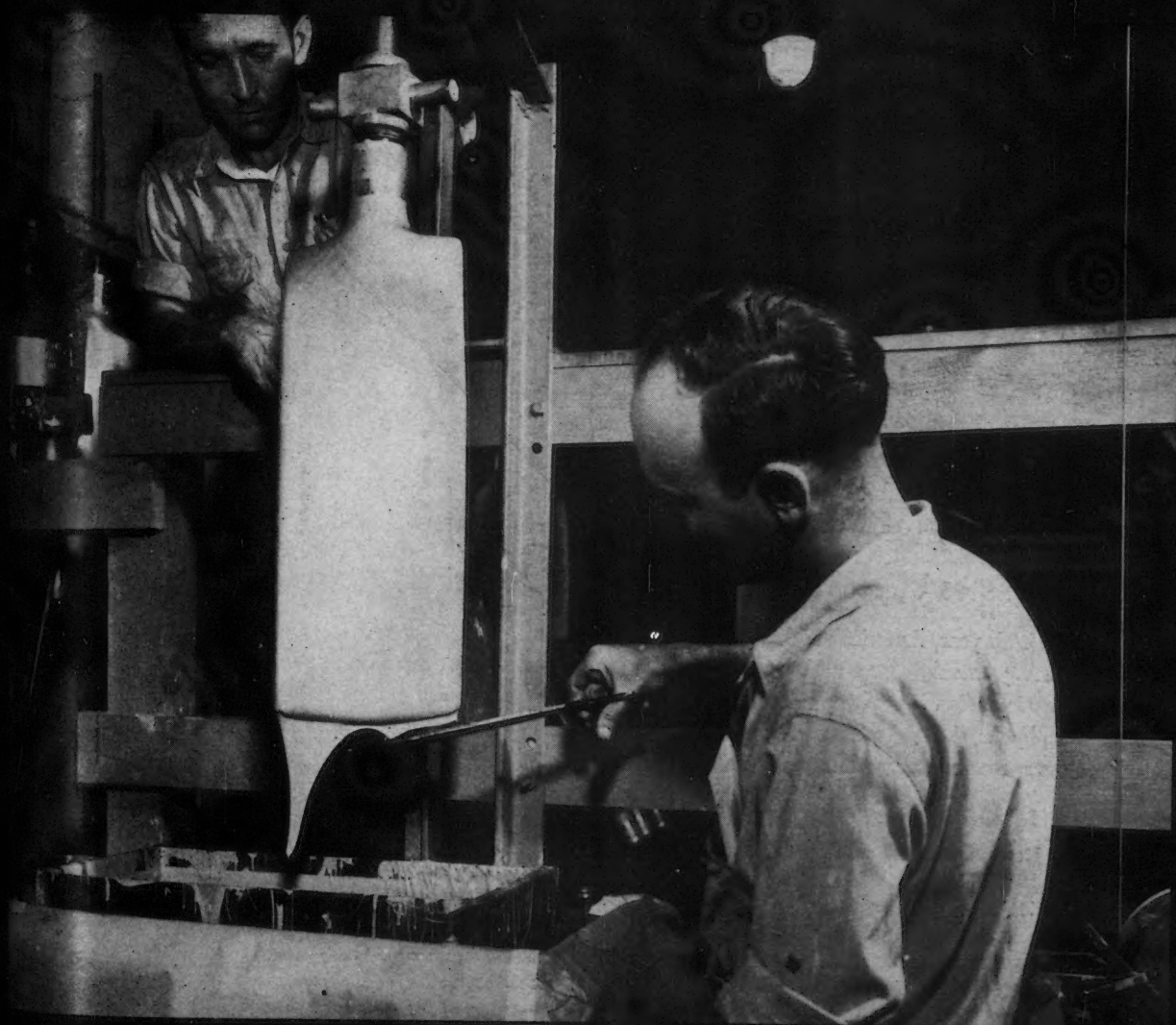
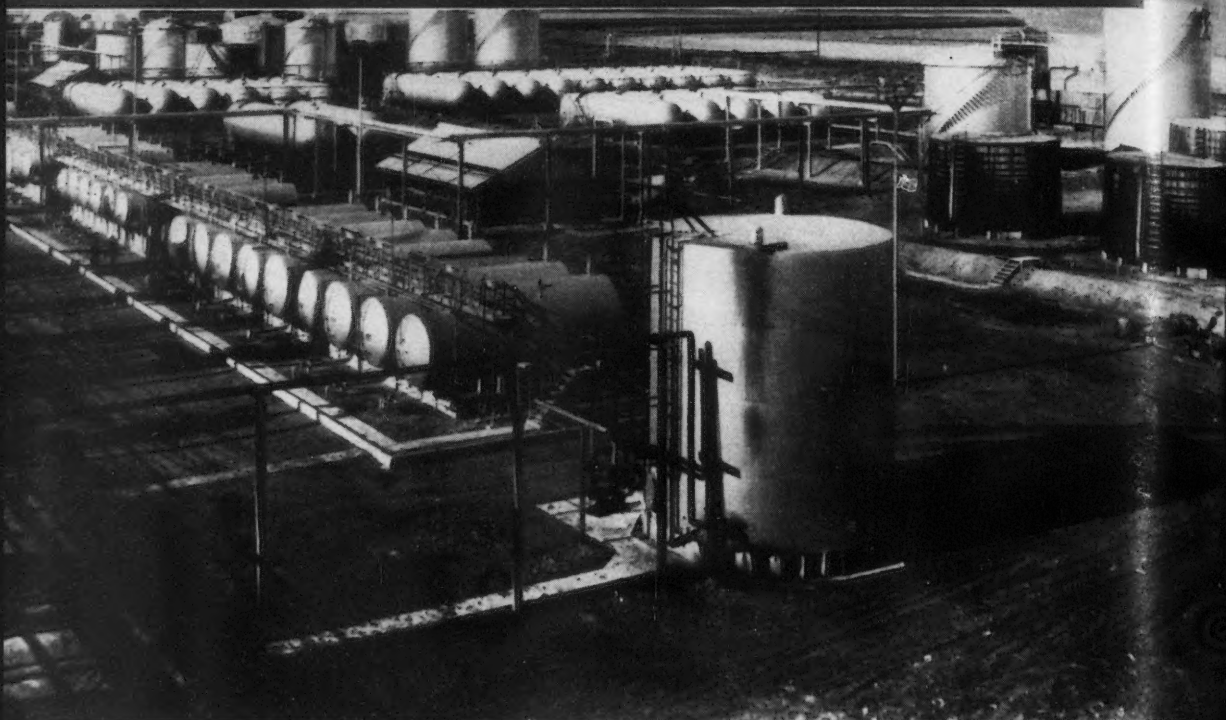


Corrosion



There's more to CORROSION than meets the eye



Sometimes VISIBLE...Often HIDDEN...Corrosion Strikes in Every Plant

This year, American Industry will pay more than \$6,000,000,000 for losses created by corrosion... *yet much of this corrosion may never be discovered* until it's too late to protect—and time to pay!

Corrosion is readily detected when it appears as rust layers or failing paint on exposed surfaces. But, by far, the major costs of corrosion come from hidden areas—where only minute inspections and constant care can prevent costly failures.

YOU LOSE IN A "WAITING GAME"

Don't wait for rust or other visible signs to appear. Visible or hidden, corrosion will destroy costly equipment...halt production...cause unnecessary maintenance shutdowns...and contaminate valuable products. Thus, corrosion dips deep into your profits as it creates needless losses totaling thousands of dollars.

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Check your plant for corrosion's presence. Double-check areas that are vulnerable to *hidden corrosion*. If you would like help, an AMERCOAT Field Engineer will gladly assist you in making a thorough analysis. There is no obligation.

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What is AMERCOAT?
AMERCOAT is a method of corrosion control. Not just a single product, but a complete LINE of coatings, individually formulated to solve or control specific industrial corrosion problems.

CORROSION



Making water work harder

Water alone won't work—it takes *soap* to get Butch really clean!

As recently as a century ago, families made their own soap by boiling kitchen fats with lye they extracted from wood ashes. But since 1837 chemical discoveries as to the nature of fats, glycerin, and alkali have transformed soap-making from a household handicraft into a giant process industry. Today this industry is making water work harder than ever with new synthetic detergents of greater wetting and emulsifying power—even in hard water or acid solutions where soaps won't work.

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These harder working "soaps" represent only a small percentage of the many new end-products of modern chemistry that flow through ALOYCO corrosion-resistant valves during their processing. ALOYCO—in its engineering, its research and testing facilities, and in its manufacturing operations—has kept pace with the technical growth of the industries it serves. ALOYCO valves go hand-in-hand with chemical progress.

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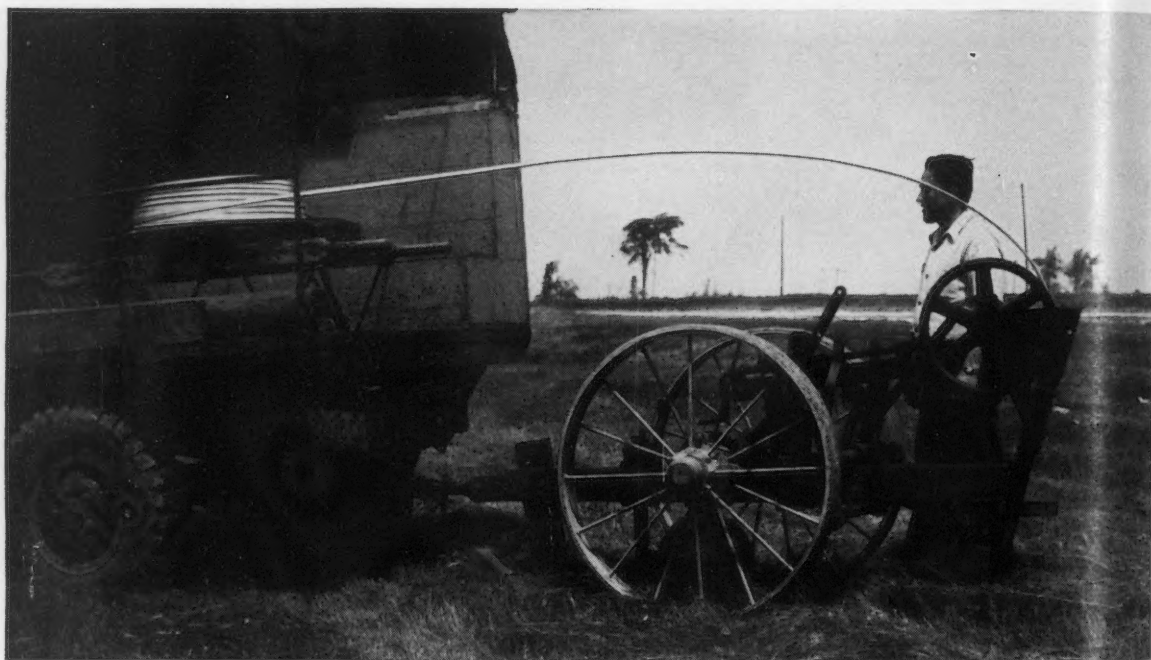


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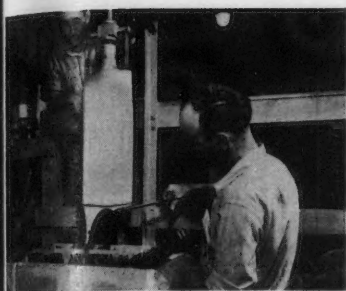
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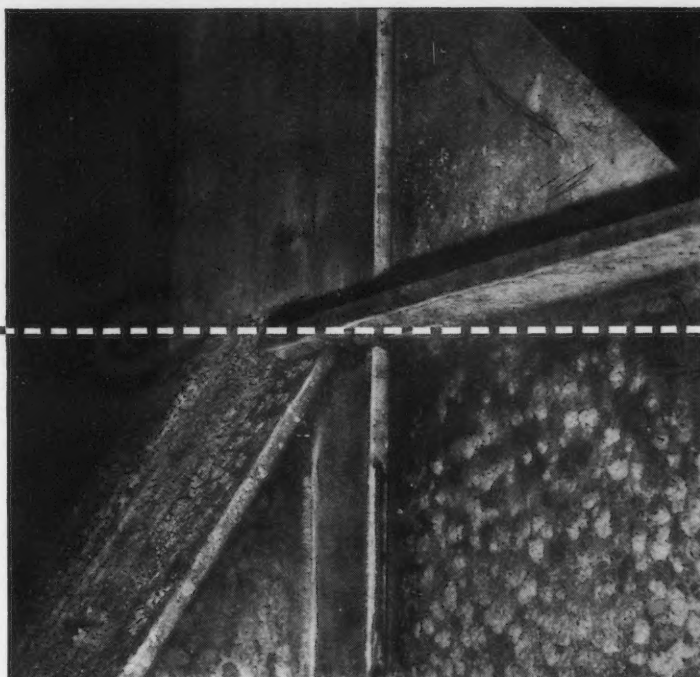


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Close-up of
steel dock piling,
showing excellent condition
of metallized portion;

serious rusting
and fouling of
painted part.



Metallized dock piling still in A-1 condition after 6 years in the Mississippi

The steel piling shown in the photograph was driven into the bed of the Mississippi River in December 1945, for a loading dock at Baton Rouge. As a test, the top fifteen feet of each pile had been metallized with .010" zinc, and the remaining portions painted. This piling is completely submerged during the greater part of each year and can be inspected only during very low water stages.

The photograph was taken in January 1950, five years after installation of the piling. It shows the metallized portion to be in perfect condition. The most recent inspection, made about one year ago, showed the zinc still protecting the steel, even where the coating had been scratched and marred by docking vessels, while the painted portions had rusted severely. The photo also demonstrates the excellent anti-fouling properties of the zinc coating.

the Metco® Systems These Systems are a series of 18 basic engineering specifications developed over 19 years of experience with pure zinc and aluminum coatings on many different types of structures and equipment. The Metco Systems provide the answer to standardization of surface preparation, metal coating thicknesses and organic after-coatings for various service conditions and appearance requirements.

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(Continued from Page viii)

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How deeply metal is immersed, particularly in a quiet solution, is another determinant of corrosive action in which dissolved oxygen is the governing factor. Oxygen saturation,

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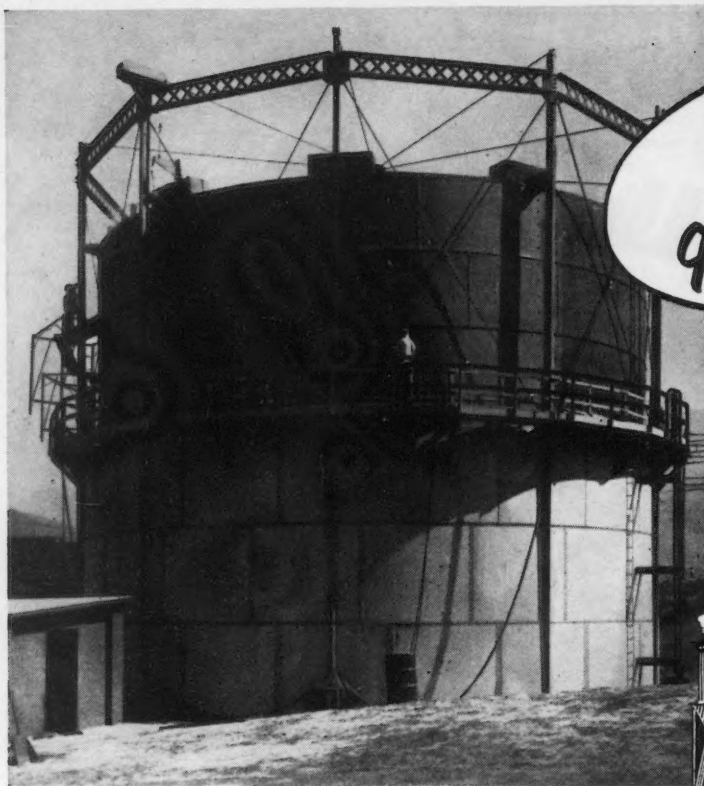
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quenching area**



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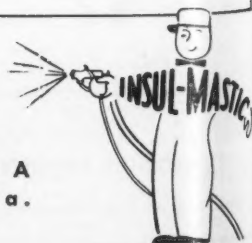
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May, 1953—CORROSION



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of mill-wrapped
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- controls corrosion

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Tensile Strength	250%	300%
Elongation at Break	Excellent	Excellent
Elasticity		
Adhesion, ozs. per inch width	30	20
Temperature Limit	200° F	200° F
Abrasion Resistance	Good	Excellent
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Dielectric Strength per mil thickness, approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
3. Chemical		
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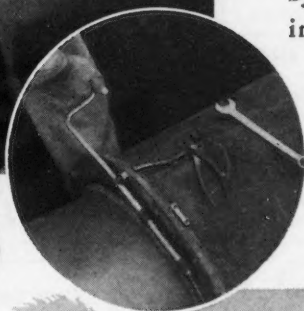
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- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
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The 1953 annual meeting of South Central Region NACE will be held at Tulsa October 7-9 at the Mayo Hotel.

NEWS FOR JUNE CORROSION Should be at CENTRAL OFFICE Houston Before May 10

NACE MEMBERS CHANGING STATUS

Notification to Central Office NACE of changes of membership status, including changes of address should be made *personally* by the member.

NACE is reluctant to make changes in membership records except when asked to do so by members themselves.

Please note also:

1. Active and junior memberships are *non-transferable*, because applications are signed personally by members, therefore
2. All persons wishing to become members of NACE must submit and *sign personally* an application containing a concise statement of qualifications and including the names of two NACE members in good standing as references.

NACE POLICY ON DUES IN ARREARS

No member of the association with dues in arrears for three months shall receive publications of the association until such dues are paid. Members in arrears one year shall be dropped automatically from membership.

If your dues are not received at Central Office by the latter part of March, you will be dropped from the list to receive NACE publications and mail. Accordingly the March issue of CORROSION will be the last received by those so dropped.

In order to avoid interrupted mail and missed copies of CORROSION members are urged to remit dues before the deadline. Much work will be eliminated at Central Office if members remit before the date stipulated.

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Sales Engineer: Married, family, 34. Solid chemical background in research, production, technical service. Recently 5 years direct and distribution sales, chemical equipment, coatings, linings, North East territory. Management experience. Prefer equipment or resins sales. CORROSION, Box 53-9.

Corrosion Engineer: BS Metallurgical Engineering, 7 years hydro-metallurgical research, 5 years plant inspector and corrosion engineer as well as plant metallurgist in high pressure, high temperature installation. Prefer Rocky Mountain area or West. CORROSION, Box 53-8.

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- To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- To promote standardization of terminology, techniques, equipment and design in corrosion control.
- To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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Report by TP-9 on Corrosion Inhibitors

List of Corrosion Inhibitors Compiled

Chairmen: R. S. Wise*, 1953-54

F. M. Watkins, 1952-53**

THE CONSTANT stream of new examples wherein corrosion inhibitors effectively stop substantial losses of equipment has provided encouragement and a strong stimulant to members of Technical Practices Committee No. 9. Our principal aim is to obtain and to pass along information on corrosion inhibitors so they will be properly used wherever they offer the most logical and economically feasible solution to a corrosion problem. We are also concerned with the best technical practices for evaluating corrosion inhibitors and with research on inhibitors.

Since TP-9 last reported to you in this column in May 1951, its members have been working to publish an alphabetical list of corrosion inhibitors. This list is intended to assemble for ready reference, pertinent information on the activity and utility of important inhibitors. It is being designed for the corrosion engineer who has a limited knowledge of inhibitors rather than for the advanced researcher who is interested in minor differences as applied to some specific application.

Relatively few materials fail to act as an inhibitor under some exceptional condition so a complete list would almost be a chemical dictionary. To avoid the resulting confusion, an attempt is being made to list only those materials whose use has attained commercial significance. Each material listed is accompanied by a literature reference, chosen to guide the reader to details on the method of application, limits of utility and other pertinent facts. Wherever possible, the references are chosen to provide by cross-references therein, a thorough introduction to related materials, their method of action and extent of usefulness as well as to characteristics of the subject inhibitor.

About fifty inhibitors have been catalogued to date.

Materials included in this list are those whose use has been described in books or in scientific or trade journals. This basis of selection by-passes many useful combinations described in patents, advertisements, or in manufacturer's bulletins, since this type of reference is oftentimes not readily available. This basis of selection also has the advantage that editorial review prior to publication will help to screen information to include the best portions based on sound experimental data and on utility to the reader. It is hoped that many of the new and better inhibitors will shortly be described in literature which can be found in the average technical library.

The most successful uses for inhibitors reported in the literature may be described in one or more of the following classes which form one basis for the listing.

In acids	Gas (and gas condensate wells)
Antifreeze solutions	Oils (lubricating)
Brine or Salt Water	Oils (crude)
Cooling Waters	Paints
Potable Waters	Volatile
Steam condensate lines	Miscellaneous
Petroleum Fuels	

Additional information being collected includes details concerning the name of suppliers who furnish each material, metals which can be protected, the preferred environment with respect to pH and temperature range and dosage which has been used successfully.

You can assist in the work of this committee by calling the chairman's attention to publications which detail the above type of information about the lesser known inhibitors. You can also help by encouraging publication of articles describing the new inhibitors, their successful application and limits of their utility. New and improved inhibitors are constantly being offered and new uses are constantly being found for them. We all profit from passing along this kind of information.

* National Aluminate Corp., 6216 West 66th Place, Chicago 38, Ill.
** Sinclair Research Laboratories, Inc., Harvey, Ill.

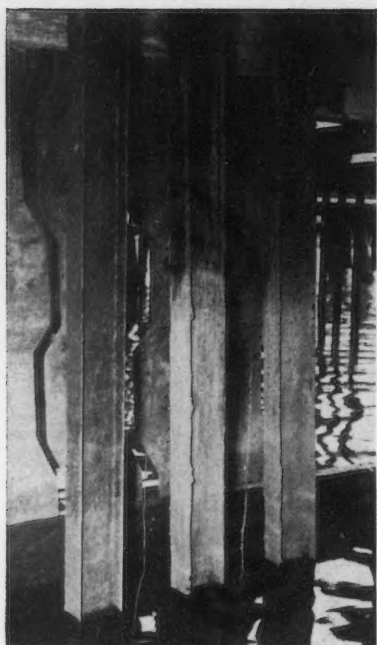


Figure 1—Three coated H-beams jettied four feet below existing harbor bottom were unaffected after over two years' exposure to marine corrosion at the Sea Horse Institute, Wrightsville Beach, N. C. The beam at left is coated with liquid Neoprene and the one in the center and the one on the right are coated with furane resin.

Plastic Materials of Construction*

By R. B. SEYMOUR

CORROSION engineers who continually face various forms of corrosion are fully aware of its tremendous cost. Their major efforts are directed towards a reduction of these costs through corrosion control. This control may be accomplished by process changes, proper selection of materials or through the use of inhibitors.

Most engineers are well informed about metals and their alloys but too few appreciate the importance of plastics as materials of construction. Therefore, an attempt will be made to present an outline of the essential applications of plastic materials in chemical resistant construction.

Because the plastic approach is relatively new and not usually taught in engineering schools, it is essential that competent corrosion engineers become self-educated in this field. As an aid to this self improvement, a guide to published literature has been compiled¹ which can be kept up to date readily. It would be redundant to suggest to a group of corrosion engineers that they join the National Association of Corrosion Engineers but this is one of the best steps that a non-member can take if he expects to make progress in the solution of corrosion problems. Foreign journals have devoted considerable space to a discussion of plastic materials of construction and CORROSION, the official journal of the NACE, is becoming known as one of the journals in this country which recognizes the importance of plastic materials in

corrosion control. This association, through its bibliographies, surveys and technical practice committees, has kept abreast of most of the advances being made in corrosion studies.

The general scope encompassed by this article has been reviewed previously^{2,3,4} but the advances taking place in this field are sufficiently rapid to make some of the contents of old articles obsolescent. In this article, plastics will be discussed from an application point of view under the headings: Protective Coatings, Impervious Linings, Chemical Resistant Cements, Masonry Construction and Structural Plastics.

Protective Coatings

More confusion exists in the protective coating field than in any other phase of plastic materials of construction. The amount of difficulty usually encountered will be diminished if attention is given to the following rules:

- A) Be sure to get adequate surface preparation.
- B) Maintain dust, dirt and fume-free atmosphere during application.
- C) Apply coatings under conditions above the dew point and at temperature and humidity above 60 degrees F and below 80 percent respectively.
- D) Brush apply a suitable priming system to the prepared surface before any rusting takes place.
- E) Brush or spray apply at least three coats of a properly selected coating to secure a minimum thickness of 5 mils.

* A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., October 1-3, 1952.

Abstract

While the major emphasis in plastics application has been in the novelty field, these materials have many chemical and physical characteristics which make them almost ideal as materials of chemical construction. In modern chemical process industry plastics are used primarily as protective coatings, linings, chemical resistant cements, joining materials and cast plastic structures. Typical applications of these materials are fairly well known but additional knowledge on corrosion resistance and physical properties is required to insure proper application.

The use of reaction vessels, towers, hoods and pipe cast from filled plastics is expected to increase as additional technical information becomes available. The greatest growth in industrial plastics application will be in the field of extruded, laminated and reinforced plastic materials based on plastics which are already available commercially. Considerable advances in research, design and application of such materials can be assured. This will permit the construction of chemical equipment heretofore considered impossible.

R. B. SEYMOUR—Executive vice-president and technical director of Atlas Mineral Products Co., Mertztown, Pa. He holds a BS in chemical engineering and an MS in chemistry from University of New Hampshire and a PhD from University of Iowa. He has been a research chemist for Goodyear Tire & Rubber Co., research group leader for Monsanto Chemical Co., director of Industrial Research Institute, University of Chattanooga. He is author of about 100 articles and patents principally in the field of chemical resistant plastics.



- F) Ascertain that each coat is essentially free from residual solvent and surface contamination before the application of additional coats.
- G) Do not subject a protective coating to conditions of immersion unless the fluid is essentially non-corrosive. Protective coatings are recommended primarily for protection against splash and fumes and not against continuous contact with liquid corrosive materials.

While a large number of different plastics have been used as coatings in the plating,⁵ petroleum,⁶ textile,⁷ paper⁸ and the chemical process industries,⁹ this discussion will be restricted to a few typical systems in order to minimize possible confusion which might result from a more comprehensive treatment.

One of the most universally useful priming systems is the so-called wash primer¹⁰ which consists of a metallic chromate inhibitor, polyvinyl butyral resin and phosphoric acid in an aqueous alcohol solution. When applied to a relatively clean surface, wash primers adhere tenaciously to steel, aluminum, zinc, copper and stainless steel to form a base for a large variety of protective coatings.

Other priming systems are based on Neoprene, oleoresinous products, alkyds, chlorinated rubber, modified vinyls, modified phenolics, butadiene-acrylonitrile copolymers or blends of these materials. It is not necessary that the primer be resistant to the corrosive atmosphere but it must inhibit under-film corrosion and serve to bond the protective coating to the surface to be protected.

The ideal coating should be inert to the corrosive environment, soluble in a non-toxic, non-flammable solvent system and readily applied over a properly prepared surface to produce a film having a minimum thickness of 2 mils per coat. It should be usable over a wide range of conditions and yield a pinhole-free coating which would be insoluble in the coating solvent and yet would not deteriorate in heat, weather or sunlight over long periods of time. Until the ideal coating is formulated, some materials discussed in this article will continue to be used in large quantities since most of them meet the major requirements for an ideal coating.

Vinyl coatings are well known and when properly applied, give adequate service under corrosive conditions to which the base resin is known to be resistant. They are available as plastisols, organosols and emulsions but their main application in protective coatings is as solutions in organic solvents. Vinyl systems are resistant to gasoline, mineral and vegetable oils, most inorganic acids, alkalis and salts.

As a result of recent marine laboratory tests, Saran has been selected as one of the better gasoline and salt water resistant coatings. Similar tests have been made with a highly filled aluminum vinyl paste. The latter product has shown considerable promise as a coating for vegetable and mineral oil storage tanks.

Considerable interest has been shown in asphalt-Gilsonite mastics which are spray-applied under high pressure to form heavy barriers. When properly applied, such coatings give adequate service in the petroleum and chemical process industry, providing their limitations are recognized.

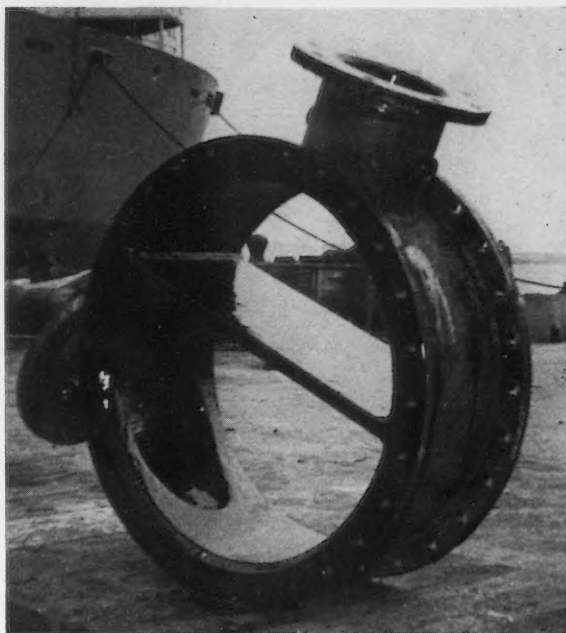


Figure 2—Water box of the auxiliary circulatory system of T-2 tankers lined with $\frac{1}{8}$ -inch thickness of Neoprene applied as a solution. (Photo courtesy S. L. Bittner & Sons, Inc.)

Chlorinated rubber coatings vie with vinyls in popularity although they are somewhat less resistant to solvents and weathering. They have excellent adhesion to concrete and steel and do not require a separate primer system. Considerable success has been experienced with a system consisting of alternate coats of vinyls and chlorinated rubber.

Styrene copolymers also have excellent adhesion to properly prepared concrete and metal surfaces. Their solvent and weathering resistance is also inferior to that of vinyl systems but they are finding a definite place in the chemical process and food industries.

Liquid Neoprene apparently comes closer to meeting the requirements of an ideal coating than any other material available. It can be applied as a heavy coating and cures at ordinary temperature to form an elastic film which is resistant to oils, gasoline, alkalis, salts, and most acids excepting nitric, chromic and hydrochloric acid. A recent improvement consists of a liquid Neoprene coating which is resistant to hydrochloric acid and can be applied in a thickness as heavy as 20 mils per coat. Liquid Neoprene has given outstanding service as a coating for shafts and as a lining for pipe, valves, sea chests and condenser heads in many ocean-going vessels. Tests over a two year period at the Sea Horse Institute, Wrightsville Beach, North Carolina, have shown that partly immersed Neoprene coated steel beams are unaffected by prevailing corrosive conditions.

Phenolic coatings have excellent acid and solvent resistance but are inherently brittle and lack resistance to alkalis. One of the recent improvements in baked phenolic coating technology has been the commercial introduction of a baked modified phenolic



Figure 3—Ion-exchange tanks lined with 1/4-inch Saran rubber.

coating that is resistant to both impact and alkaline conditions.¹¹

Epoxy resins formed by the reaction of bisphenol and epichlorohydrin are also resistant to alkalis and have outstanding adhesion to a wide variety of surfaces. They can be applied as baked-on or room-temperature catalyzed coatings. The latter can be sprayed readily using a gun in which the uncompounded coating and catalyst are mixed at the nozzle.

The so-called furane resins formed by the polymerization of furfuryl alcohol or furfural have many of the properties outlined for an ideal coating. They are resistant to a wide variety of solvents, salts, alkalis and acids but are inherently brittle. Progress has been made towards overcoming the latter deficiency and it may be predicted that the use of furane resin coatings will increase in the chemical process industry.

Impervious Linings

The major difference between a coating and a lining is thickness. Most industrial protective coatings range from 5 to 20 mils while linings are usually 100 to 250 mils thick. There are borderline cases, of course, and multiple coats of a protective coating may be applied occasionally to produce a serviceable lining. Actually, laboratory tests conducted over a period of several years, have shown that protective coatings applied under ideal conditions are adequate as linings. However, since it is almost impossible to secure ideal conditions, a sizable factor of safety must be present to compensate for unavoidable application errors.

Properly constructed steel or concrete tanks may be protected from attack by corrosive process liquors through the application of a properly selected lining material. Concrete tanks should be vibrated and properly puddled to prevent the formation of a honeycomb structure. It is important that a silica rather than a limestone aggregate be used. The tank must be water-tight, free from imperfections and its interior must have a smooth surface. Steel tanks must be water-tight and free from laminations or other physical imperfections. If 1/4-inch plate is used, it must weigh no less than 10.2 pounds per foot. Welds must be continuous and smooth and all corners must be ground to a radius of approximately 1/8-inch.

The lining of concrete and extremely large metal tanks must be done in the field. However, when tanks are transportable, they should be lined in a shop

where working conditions are under better control than those in the field. No plastic or rubber linings should be subjected to mechanical abuse or to high temperatures. Likewise, solvents which may swell the lining should not be present, since they will cause the membrane to become permeable to the corrosives. Even superficial oil on steel articles to be pickled is enough to cause failure of a rubber membrane lining.

It is essential that the primer or the lining be applied to freshly sandblasted steel before any rusting has taken place. No air pockets should be allowed to remain behind the membrane and all seams must be completely tight. If there is danger of mechanical abuse or if the operating temperatures are above 150 degrees F, the lining should be protected by brick joined with a suitable chemical resistant cement.

The ideal chemical resistant lining should be applied as sheets which could be readily adhered to the surface to be protected and joined together to obtain a monolithic lining. When subjected to a simple curing process, the sheet should become resistant to all acids, alkalis, solvents and corrosives at temperatures from 10 to 170 degrees F. The sheet should be resilient and remain unchanged after long term exposure to weather, sunlight and corrosive conditions.

Natural rubber linings are far from ideal but have been standard for many years.¹² They are not satisfactory for use with solvents, chromic or nitric acid and should not be used at temperatures above 150 degrees F. They are satisfactory for service with phosphoric acid, many corrosive salts, alkalis in all concentrations and sulfuric acid in concentrations up to 50 percent.

Neoprene sheet linings can be used for essentially the same service as natural rubber. Because of inherent permeability, they are unsatisfactory for hydrochloric acid but are more resistant to gasoline and will withstand somewhat higher temperatures than natural rubber. Heavy coatings may be built up from liquid Neoprene when the use of sheet lining techniques is not practical.

Compounded Saran rubber sheet was introduced commercially about four years ago and has given satisfactory service in the presence of sulfuric acid, hydrochloric acid, many salts and some alkalis at temperatures up to 150 degrees F. Since it is extruded rather than calendered, it is denser than many other sheet stocks.

Plasticized polyvinyl chloride has been available commercially as a sheet lining for almost twenty years. When properly applied, it is resistant to oxidizing acids such as nitric and chromic acid, to some solvents and to most corrosive salts and alkalis at temperatures up to 150 degrees F. A polyvinyl chloride liner plate is now available for lining concrete pipe. Unlike standard polyvinyl chloride sheet which is adhered to the surface to be protected, these plates depend upon mechanical forces to hold them in place. Obviously, liquids infiltrating through the concrete will weaken the physical bond and cause failure.

Polyethylene has chemical resistant properties similar to polyvinyl chloride. It is available as a flame sprayed coating as well as a sheet lining. Polyethylene linings have proved to be satisfactory for

chlorine dioxide, nitric acid and chromic acid service and for ordinary corrosives such as those usually handled by natural rubber. Concrete tanks may be lined with a more economical asphalt-type lining but this lining must be protected by brick joined with a properly selected chemical resistant cement.

Since many chemical processes require both acid and solvent resistance, considerable interest has been shown in Fiberglass-reinforced furane resin linings. In spite of the characteristic brittleness of these linings, they have been used successfully in many instances. However, they are far from fool-proof and cannot be considered as standard materials of construction at present.

Another approach toward securing combined solvent and acid resistance has been through the use of multiple courses of brick or tile in the absence of a flexible membrane. In some instances, the back course is embedded in Portland cement and the front course is embedded in a thermosetting chemical resistant material such as a furane cement. In this type of construction, it is essential that a layer of chemical resistant cement be placed between courses and that all joints be staggered. This type of construction has been standard for many years in the pulp and paper industry but it is far from trouble-free and requires some maintenance. Some improvement has been made through the use of corrosion resistant cements in all courses.

Chemical Resistant Cements

Too few engineers are acquainted with the broad field of corrosion resistant cements. Many plant men are familiar with only one generic material, viz., silicate cement. This product has excellent resistance to concentrated sulfuric, nitric and chromic acids¹³ but because of its high water absorption, should not be used when plastic cements will solve the problem. It is not satisfactory for service at a pH greater than 6 nor in the presence of fluorides or crystallizable salts.

An ideal chemical resistant cement should have a long storage life, should be readily mixed or melted and have no deleterious effect on the installer. It should be ready for service shortly after installation, have high adhesion to ceramic surfaces and be resistant to a wide variety of acids, alkalis, solvents and corrosive salts at temperatures from 10 to 325 degrees F.

Plasticized sulfur cements are far from ideal but have been accepted as standard for many types of chemical resistant construction for over twenty years. They are satisfactory for operating temperatures of 10 to 200 degrees F in the absence of alkalis, solvents and strong oxidizing acids.¹⁴ A plasticized sulfur cement should have a tensile strength above 500 psi, a compressive strength of at least 5000 psi and a coefficient of expansion of not more than 10×10^{-6} inches per degree Fahrenheit. Data on the physical properties of sulfur cements have been published¹⁵ and tentative specifications have been proposed.¹⁶

Phenolic resin cement was developed in Germany approximately twenty years ago and has had wide application in this country. It is resistant to many different salts, acids and solvents^{17,18} but because of

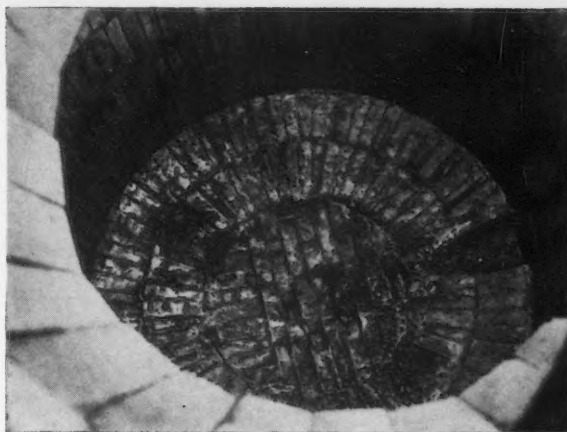


Figure 4—View from the top down through manhole of a chlorinator in which the steel is protected by rubber lining which in turn is protected by carbon brick joined with a furane cement.

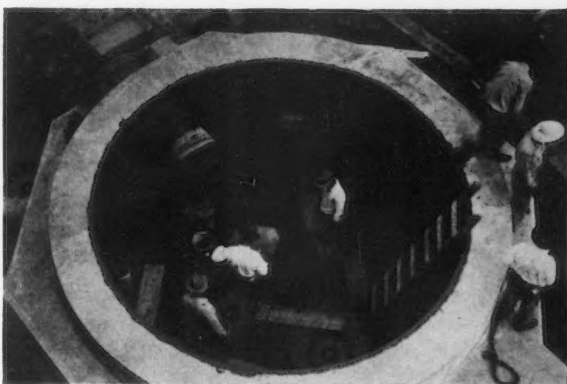


Figure 5—Concrete circular tank with brick lining in process of construction. Concrete surface is protected by an asphaltic triple-layer membrane which is in turn protected by brick joined with a plasticized surfur cement.



Figure 6—Brick floor in a chemical process plant in the process of construction. Brick laid on an asphaltic membrane and joined with a phenolic cement.

the characteristic instability of the liquid resin under ordinary storage conditions and the lack of the resistance of the cement to alkaline solutions, it is being replaced in part by the so-called furane resin cement.

The original furane resin cement was based on a bodied furfuryl alcohol which was converted to an infusible mass when mixed with an inert filler containing an acid catalyst.¹⁹ Modern furane cements are based on polymers of furfuryl alcohol or condensates

of furfuryl alcohol and furfural which are mixed on the job with a catalyst-containing filler to form infusible products. Furane cement ingredients are stable under ordinary storage conditions, are readily mixed and applied and should not contribute to dermatitis or skin disorders. Since they are resistant to alkalies, salts, solvents and all non-oxidizing acids, they are the nearest approach to an ideal cement that has been developed to date.²⁰

One of the principal objections to furane cements is their inability to cure in contact with metals or Portland cement. Some recent improvements overcome this objection to a large extent. However, even improved furane cements do not adhere to steel or concrete surfaces.

Two basically different chemical resistant cements which will actually adhere to both Portland cement and steel have been developed recently. One is a modified phenolic cement which cures on the alkaline side and the other is a plastic cement which cures under neutral conditions. Insufficient data are available to permit drawing final conclusions but both will apparently find a place as materials of chemical construction. The modified phenolic cement is resistant to both acid and alkaline solutions. The plastic cement is resistant to most acids, corrosive salts and mild alkalies. It is one of the few cements that will withstand chlorine dioxide.

While chemical resistant plastic cements were developed primarily for joining brick and tile, they have found many other applications since they change readily from a liquid to an inert solid. They are often used as patching materials in chemical plants and breakdowns in chemical equipment are often prevented through the judicious use of these cements. Sulfur cements have been widely used for setting equipment in concrete. The neutral and alkaline catalyzed plastic cements have been used to line concrete pipe and tanks. The lined pipes can be formed in situ and can be used for mild acid service. The plastic cement does not serve as a complete lining for concrete tanks but since it adheres tenaciously to concrete surfaces, it does help overcome imperfections and presents a smooth surface for membrane lining application.

Masonry Construction

The essential requirements for proper floor construction in chemical plants have been reported previously.²¹ Since many floors already installed are inadequate for the corrosive service condition, a patching technique has also been developed.²²

The standard chemical resistant floor consists of an impervious membrane applied on the primed concrete slab. The membrane is in turn protected by brick or tile joined with a properly selected chemical resistant cement. The thickness of brick is determined by the loads and mechanical abuse to which the floor will be subjected under actual service conditions. When mild conditions exist as in food plants, it is possible to eliminate the corrosion resistant membrane and to use tile joined with a furane cement.²³

Contrary to the opinions sometimes expressed by tank designers, brick linings must be self-supporting

structures, separated from the rigid steel or concrete shell by impervious membrane. Claims have been made concerning the adhesion of brick to rubber and plastic membranes but any such adhesive force would tend to prevent independent movement of the brick and shell and would encourage failure of the unit.

It is absolutely essential that the impervious membrane be bonded to the rigid shell but there should be as little adhesion as possible between the brick work and the membrane. When this requisite is accepted, the need for adequate design for the brick lining becomes obvious. Brick linings must serve to protect the membrane by reducing temperature, minimizing circulation of corrosive liquids in contact with the membrane and eliminating possible physical damage to this membrane.

Acid brick should be highly vitrified, structurally strong, free from laminations, dense enough to prevent crystal formation within the pores and have a sufficiently rough surface to insure a strong bond with the jointing compound. They should have a compressive strength of at least 8000 psi and a water absorption of less than 3.0 percent. Acid brick will withstand all corrosive salts, mild alkalies and all acids except hydrofluoric acid. Carbon brick must be used for hydrofluoric acid or highly alkaline service.

The temperature drop through brick work in a lined steel tank will depend on the temperature gradient between the atmosphere and the process liquor. For example, four inches of brick will cause a temperature decrease from 212 degrees to 150 degrees F and eight inches of brick will cause the temperature to be reduced to 125 degrees F in a rubber lined steel tank.²⁴ Insulation on the outside of the tank or imperfections in the brick lining will reduce the temperature drop. Since carbon brick are more highly conductive than shale brick, the temperature drop through carbon brick will be less than through regular acid brick.

The coefficient of expansion of masonry linings and the protective steel shell, vary considerably over the range of temperature usually employed in a chemical process industry. Organic membrane linings, such as rubber are resistant to abrasion but are deficient in their resistance to sharp objects. Therefore, it is essential that hard infusible materials, such as furane and phenolic cements, not be used in direct contact with rubber-like membrane linings in rectangular vessels. This inherent deficiency in rubber linings has been overcome in part through the use of so-called dual construction²⁵ in which a plasticized sulfur cement is used in the back course and an infusible resin cement to join the brick in the front course. Such construction can be used at temperatures much higher than are possible with sulfur cements alone.

In tanks having straight sides longer than twelve linear feet, expansion joints must be used to compensate for differences in expansion throughout the structure. Satisfactory expansion joints have been developed which permit the construction of brick lined tanks greater than 200 feet in length.^{26, 27}

Pipe Joints

The joining of vitrified clay pipe used for the disposal of chemical plant wastes has been the subject

of considerable investigation. Hot-filled asphalt compositions have been used for solvent-free mild corrosive conditions at ordinary temperature²⁸ but these joints are obviously inadequate for more strenuous conditions. The requirements for an ideal joint have been published and a close approach to this is now available commercially.²⁹

A truly chemical resistant joint has been developed for vitrified clay pipe lines used for the disposal of chemical process wastes. This joint consists of a furane cement which is in contact with the waste materials and is backed up by a plasticized sulfur cement which fills up the remainder of the annular space and strengthens the joint in an inexpensive manner.

All Plastic Structures

Carbon pipe and equipment impregnated with a polymer of furfural have been commercially available for over ten years.³⁰ This product is resistant to a wide variety of corrosive materials and has found a definite place in the chemical process industry.

Plastic cements with or without asbestos filler may be cast to form pipe, tanks and other chemical resistant equipment. A Fibreglas-reinforced furane pipe has been developed and is available commercially from several manufacturers.³¹ The physical and chemical properties of polyester pipe and structures which are also used in the chemical process industry have been reported.^{32,33} These products have excellent resistance to mechanical shock, non-oxidizing acids, corrosive salts, weak alkalies and aliphatic and aromatic hydrocarbon solvents.

Furane and polyester pipe may be joined by simply wrapping straight end pipe with Fibreglas impregnated with a plastic cement of similar composition and allowing the cement to cure while it is stationary. A modification of this technique consists in using small sections of larger size pipe to further reinforce this wrapped joint. Ceramic and porcelain pipe are now protected from mechanical and temperature shock by armoring with Fibreglas-reinforced resin cement.

Corrosion engineers in chemical plants on the European Continent, especially those in Germany and Italy, have been cognizant of the advantages of plastic structures for many years. For example, the annual consumption of rigid polyvinyl chloride plastic in Germany was over 10,000,000 pounds some ten years ago. However, such materials were not used widely in American industry until after various technical groups visited German industry following the end of hostilities of World War II. As a result of these inspection trips, foreign-made polyvinyl structures were imported to this country and have found a place in our chemical industry.

As a result of additional research during the past several years, American-made pipe, ductwork, hoods and chemical equipment fabricated from rigid polyvinyl chloride, polyethylene, cellulose acetobutyrate and styrene copolymers are now available commercially in this country. Most of the pipe formed by these materials is manufactured by extrusion and may be threaded and joined with suitable fittings using techniques similar to those employed with metal pipe. Sheet stock is usually calendered and

laminated to various thicknesses. These sheets may be drawn, welded or cemented to form structures of almost unlimited size. Typical manufacturing techniques have been described.³⁴

Polyethylene pipe and structures are resistant to a wide range of aqueous corrosives at temperatures up to 125 degrees F and are extensively used.³⁵ Polyethylene sheet may be heat-formed and welded using round welding rod to join pieces with beveled edges at a 50-70 degree angle. The strength of the weld should be at least 75 percent of the sheet itself and the chemical resistance of the welded section should be similar to that of the original sheet.

Cellulose acetobutyrate piping has been used to good advantage in many oil fields. It cannot be welded but pieces can be cemented together using a solution of the plastic in an organic solvent. It is resistant to gasoline, mineral oil, alkalies and some corrosive salts but is not resistant to acids and many organic solvents.

Polymethyl methacrylate sheet and pipe has been used to some extent in the plating industry. Saran has been used throughout the chemical process industry as plastic pipe and as Saran lined metal pipe. High impact styrene copolymers are less resistant to solvents and oxidizing acids than some of the other plastics and cannot be heat-welded. However, because of their high impact strength and low specific gravity, they are being used industrially.³⁶ Structures of high impact polystyrene copolymers are assembled by use of adhesives or by specially constructed clamps and corner locks.

Rigid polyvinyl chloride pipe and structures possibly have a greater potential than other commercially available plastics for use as pipes, ductwork, hoods and small tanks. Rigid polyvinyl chloride meets most of the requirements for an ideal structural plastic since it has high tensile and compressive strengths (approximately 10,000 psi), fair impact resistance, will not burn and is resistant to almost all inorganic acids, corrosive salts, alkalies and many solvents at temperatures from 15 degrees to 160 degrees F.³⁷ It is commercially available as pipe in sizes ranging from one half inch to two inches in diameter. Fittings molded to fit standard threaded pipe are available for joining threaded plastic pipe.

Conclusions

Unfortunately, too little knowledge about the physical and chemical properties of structural plastics is available to the American engineer. Obviously, even less information is available on plastic materials of construction. However, in a large number of cases, knowledge at hand has aided corrosion engineers in the solution of problems both in this country and abroad which were previously considered without answers. It is important that the American corrosion engineer recognize what has been accomplished in this field and gain more knowledge so he can make a greater contribution to the solution of corrosion problems in the American chemical process industry.

Acknowledgment

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DISCUSSION

Discussion by H. E. Waldrip, Gulf Oil Corp., Houston:

Dr. Seymour is to be commended on a very informative paper. The field of plastics he describes is so large it cannot be covered in detail in one paper. The role of plastics in protective coatings, impervious linings, cements, joints and construction materials is so new that few engineers have had any basic training on the subject. The field is so specialized that the majority of us depend on men like the author to keep us informed of the advances being made. It is through such meetings as the South Central NACE that such information can be disseminated.

In discussing protective coatings, Dr. Seymour lists seven precautions in the line of surface preparation and application. Had space and time permitted he could have multiplied these precautions several times. No phase of a coating system, plastic or otherwise, is more important than surface preparation. Next, it is also very important to know how, when, and where to apply the coating. While there are several different types of surface preparation, only the best is generally satisfactory under plastic type coatings. Dry sandblasting to clean metal or acid pickling to clean metal are probably the best and most satisfactory methods of surface preparation. The cleanliness of the metal surface as well as the physical condition, such as an anchor pattern from blasting, make for a more permanent, better bonded plastic coating job.

G. W. Seagram, in an article "The Importance of Surface Cleaning for Metal Finishing" made the statement: "The greatest bottleneck to improved paint performance is lack of knowledge at the application level." Not only is this statement true for conventional paints, but it is even more important when dealing with plastic coatings. Too many poor jobs result from misusing an otherwise good material. In cases of coating failures the blame is placed on the material instead of on surface preparation and application where it may rightfully belong.

The sooner we of industry realize that testing, selecting and specifying suitable materials is not sufficient, a big step will have been taken. We must anticipate future demands, pre-test materials in order to make suitable selections and emphasize the importance of coatings in the original design of the structure. The elimination of unnecessary sharp edges, pockets and relatively inaccessible areas are a few of the factors entering into this design for better coatings and linings. We must write rigid specifications, adequately inspect and supervise surface preparation so as to obtain from a coating system the properties the manufacturer has worked hard to develop. I am referring here to the manufacturer of quality materials. There is no place in the corrosion field for the coating "chiseler." A coating that is un-

suitable for the purpose for which it is sold is soon found out and it isn't long before everyone knows about it. Likewise, the news soon spreads regarding a superior coating.

As consumers of plastics we are interested in the general type, its resistance to various environments, nominal film thickness, resistance to abrasion and average cost per square foot. Actually, the cost per square foot per year is the best common denominator to use in the comparison of coatings.

While I am not as familiar with linings and cements as I am with coatings, I believe that the majority of my comments would apply equally as well to them.

Reply by R. B. Seymour:

I heartily agree with Mr. Waldrip's comments although possibly he has placed undue emphasis on protective coatings. Of course, he has recognized that it has been impossible to present a complete treatise and the article is essentially an outline. However, the references have been selected carefully to provide considerable additional information for the reader. We are also writing a 500 page book on the general subject of plastic materials of construction.

It should be noted that Frank L. Whitney, Jr. and I had an opportunity to compare notes before presenting our respective papers. Thus, duplication was avoided and some of the shortcomings of my paper were compensated by Whitney's able presentation.

Contrary to Mr. Waldrip's statement, while his remarks are applicable to coatings, they do not usually apply to linings, cements and plastic structures. Most of the headaches, boners, misrepresentations and

failures in the entire plastic field have been associated with protective coatings. As a result, too few consumers see the entire line of plastic materials of construction in the proper perspective.

Perhaps the difference between failures with coatings and success in other plastic applications is associated with the relative number of manufacturers in the respective fields. The producers of chemical resistant cements, linings and plastic structures are fewer in number, more technical and conservative in nature and perhaps somewhat more substantial financially. For example, there are over 500 manufacturers of vinyl paints alone and less than a score of manufacturers of chemical resistant cements and linings. The latter products are usually engineered and sold on a technical basis rather than over the counter as miracle materials.

Because of their newness and the small number of producers, there have been very few failures with fabricated plastics. I know that Mr. Waldrip and other corrosion engineers will be reassured to learn that a division of the Society of the Plastics Industry has been formed with the object of minimizing the misapplication of fabricated plastic structures in industry.

It is a little late to attempt an educational program of this kind in the coatings field but the corrosion engineer consumer need no longer be at the mercy of what Mr. Waldrip has called the coating chiseler. The consumer is still the boss but he must not be a naive boss. The reader is referred to reference No. 9. This article which appeared in the March, 1953 issue of *ORGANIC FINISHING*, supplies the type of information that the consumer requires in the protective coatings field.

A Method for Determining the Resistance Of Insulating Joints and Pipe Line Coatings *

By H. F. KOESTER*

IT IS IMPORTANT that the electrical resistance of a pipe-line coating be known to insure the safe and efficient operation of the line from a corrosion standpoint. Coating resistance should be determined from time to time to ascertain the condition of the pipe coating and whether faults have developed.

On coated pipe lines, in which insulating joints or couplings are installed it is desirable that not only the pipe-coating resistance but also the insulating joint resistance be known. On such lines, a determination of the insulating joint resistance cannot be made without a knowledge of the pipe coating resistance on each side of the joint. Similarly, the pipe coating resistance of a section between insulating

Abstract

A method is given by which the true resistance of both insulating joints and pipe coating can be determined. It combines field resistance measurements and algebraic computations of true resistances. Detailed instructions are given for the placement of test points and the formulae are explained. A special method for use with poorly coated or uncoated pipe lines is explained. The method outlined has been adopted in the New York City area and has been found satisfactory.

joints cannot be ascertained without knowledge of the resistances of the insulating joints at each end of the section.

Measurements of insulating joint resistance made by conventional field methods always will be influ-

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enced by current leakage effect through coatings of the adjacent sections. Similarly, a measurement of coating resistance of a pipe section between insulating joints is influenced by the current leakage effect of the adjacent insulating joints.

The following method was developed to evaluate the true resistance of both the insulating joints and the pipe coating. This method is based on the use of a combination of field resistance measurements for the algebraic computations of the true resistances.

Figure 1 shows two coated pipe sections connected by an insulating joint. The resistance of the insulating joint is represented by X and the resistance of the pipe coatings to ground of the two sections is represented by Y and Z.

Figure 2 shows these three resistors diagrammatically in their symbolic form and to this diagram is added the measured resistance values A, B and C as shown in Figure 3.

By analysis it will be seen that the measured values A, B, C form a triangle whereas the individual resistance values X, Y, Z may not necessarily form a triangle but are in a parallel-series combination in such a manner that their individual values cannot be measured directly but always in combination with each other.

A resistance measurement A between the points 1 and 3 of the triangle, (Figure 3), not only includes the resistance X but also the series resistance of Y plus Z which is in parallel with X. Similarly, the resistance measurement B between the points 1 and 2 will not only include the resistance Y but also the series resistance of X plus Z which is in parallel with Y, and a resistance measurement C between the points 2 and 3 will include the resistance Z with the series resistance of X plus Y in parallel.

The three measured resistances A, B and C thus can be expressed in terms of the true resistances X, Y and Z by three algebraic equations for parallel-series resistances as follows:

$$A = \frac{1}{\frac{1}{X} + \frac{1}{Y+Z}} \quad B = \frac{1}{\frac{1}{Y} + \frac{1}{X+Z}} \quad C = \frac{1}{\frac{1}{Z} + \frac{1}{X+Y}} \quad (1)$$

By simplifying the denominators these equations may be rewritten.

$$A = \frac{X(Y+Z)}{X+Y+Z} \quad B = \frac{Y(X+Z)}{X+Y+Z} \quad C = \frac{Z(X+Y)}{X+Y+Z} \quad (2)$$

Since these three independent equations contain three unknowns they may be solved simultaneously by algebraic methods with the following results:

$$\begin{aligned} X &= \frac{AB + BC + AC - \frac{1}{2}(A^2 + B^2 + C^2)}{B + C - A} \\ Y &= \frac{AB + BC + AC - \frac{1}{2}(A^2 + B^2 + C^2)}{A + C - B} \\ Z &= \frac{AB + BC + AC - \frac{1}{2}(A^2 + B^2 + C^2)}{A + B - C} \end{aligned} \quad (3)$$

The numerators of these equations are alike and

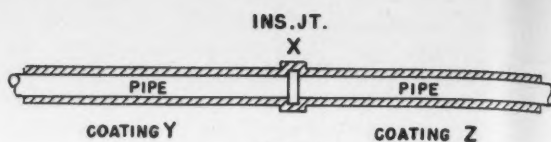


Figure 1

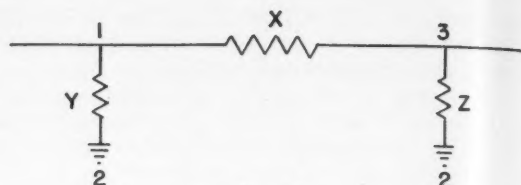


Figure 2

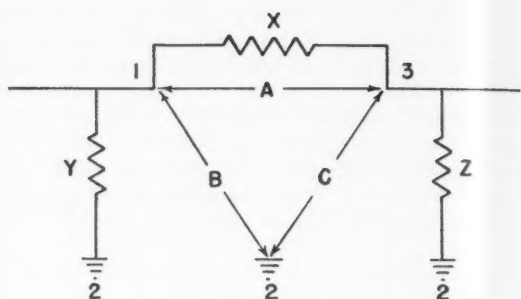


Figure 3



Figure 4

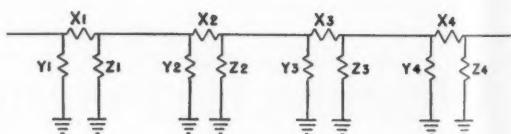


Figure 5

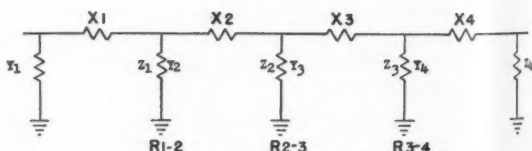


Figure 6

can therefore be represented by the letter K such as:

$$K = AB + BC + AC - \frac{1}{2}(A^2 + B^2 + C^2) \quad (4)$$

Then the above three equations can be rewritten as follows:

$$X = \frac{K}{B + C - A} \quad Y = \frac{K}{A + C - B} \quad Z = \frac{K}{A + B - C} \quad (5)$$

In this calculation the resistance value X not only includes the resistance of the insulating joint proper but also that part of the pipe line which lies between

points of test contact on each side of the joint. The resistances Y and Z represent the pipe coating resistances on each side of the joint from the point of test contact to the end of the pipe line and includes all the pipe and contact and leakage effects.

On a pipe line with many insulating joints as shown in Figure 4, the resistances Y and Z are not the true coating resistances of the pipe sections immediately adjacent to the joint under test because of the leakage effect through the adjacent insulating joints. To determine the true value of the pipe coating resistance of a given section between two insulating joints, tests must be made at both joints enclosing that section and from the results as computed by the above equations the true resistance can be determined as follows.

In Figure 4 is shown a pipe line having insulating joints 1, 2, 3 and 4. In Figure 5 is shown the schematic diagram of the calculated resistances X, Y and Z as determined at the insulating joints 1, 2, 3 and 4, respectively. In Figure 6 is shown the schematic diagram of the true coating resistances after corrections for leakage through adjacent insulating joints have been made.

The true coating resistance R_{2-3} (Figure 6,) of a given section between two insulating joints 2 and 3 (Figure 5) may be computed by the algebraic equation for parallel resistors. If this determination is made for the resistance of Y_3 at joint 3 (Figure 5) and this is to be corrected for the series-parallel resistance of $X_2 + Y_2$ at joint 2, then the equation is as follows:

$$R_{2-3} = \frac{1}{\frac{1}{Y_3} - \frac{1}{X_2 + Y_2}} = \frac{Y_3 (X_2 + Y_2)}{X_2 + Y_2 - Y_3} \quad (6)$$

And if the determination is made for resistance Z_2 at joint 2, which is to be corrected for the series-parallel resistance of $X_3 + Z_3$ at joint 3, then the equation is as follows:

$$R_{2-3} = \frac{1}{\frac{1}{Z_2} - \frac{1}{X_3 + Z_3}} = \frac{Z_2 (X_3 + Z_3)}{X_3 + Z_3 - Z_2} \quad (7)$$

Since both equations solve for the same coating resistance the answers of both should be the same.

The correction for the pipe coating resistance, as shown above, need not be carried beyond one set of adjacent insulating joint and coating resistances because the error caused by the leakage through additional insulating joints is insignificant.

The solution of the above equations is illustrated in the following example:

Coating resistance determination to be made for section between joints 2 and 3.

Resistances measured at joint 2 $A_2 = 70$ $B_2 = 30$ $C_2 = 50$

Resistances measured at joint 3 $A_3 = 60$ $B_3 = 50$ $C_3 = 20$

Solving for K: $K = AB + BC + AC - \frac{1}{2} (A^2 + B^2 + C^2)$

At joint 2: $K_2 = 70 \times 30 + 30 \times 50 + 70 \times 50 - \frac{1}{2} (70^2 + 30^2 + 50^2) = 2950$

At joint 3: $K_3 = 60 \times 50 + 50 \times 20 + 60 \times 20 - \frac{1}{2} (60^2 + 50^2 + 20^2) = 1950$

Solving for X, Y and Z by use of "K"

$$X = \frac{K}{B + C - A} \quad Y = \frac{K}{A + C - B} \quad Z = \frac{K}{A + B - C}$$

$$X_2 = \frac{2950}{30 + 50 - 70} = 295$$

$$X_3 = \frac{1950}{50 + 20 - 60} = 195$$

$$Y_2 = \frac{2950}{70 + 50 - 30} = 33$$

$$Y_3 = \frac{1950}{60 + 20 - 50} = 65$$

$$Z_2 = \frac{2950}{70 + 30 - 50} = 59$$

$$Z_3 = \frac{1950}{60 + 50 - 20} = 22$$

Solving for true coating resistance R_{2-3} by correcting Y_3 and Z_2 for series-parallel resistances at joints 2 and 3, respectively.

$$\text{At joint 3, } R_{2-3} = \frac{1}{\frac{1}{Y_3} - \frac{1}{X_2 + Y_2}} = \frac{1}{\frac{1}{65} - \frac{1}{295 + 33}} = 81 \text{ ohms}$$

$$\text{At joint 2, } R_{2-3} = \frac{1}{\frac{1}{Z_2} - \frac{1}{X_3 + Z_3}} = \frac{1}{\frac{1}{59} - \frac{1}{195 + 22}} = 81 \text{ ohms}$$

	Joint 2	Coating ₂₋₃	Joint 3
Measured Resistance	70 ohms	50 ohms	60 ohms
True Resistance	295 ohms	81 ohms	195 ohms

To facilitate field testing it is essential that the pipe line on which the tests are to be made is equipped with a set of test leads at each insulating joint, as shown in Figure 7. The leads should be solid wire, about No. 8 B & S gauge, insulated and lead covered. The wires should be welded to the pipe close to and one on each side of the joint. The leads should be brought to the street surface and terminated in suitable iron boxes. If no provisions have been made for such test leads at the time of the pipe installation, then an excavation has to be made to the top of the joint so that contact can be made to the pipe for such tests.

If the pipe line and the insulating joints are very poorly coated or uncoated, then it is advisable to have two sets of test leads installed on each side of the joint, one set is to be used for the test current and the other set for the potential measurements. This arrangement avoids the inclusion of the IR drop of the current leads in the resistance measurements. This IR drop may be large on non-coated pipe lines, but can be ignored on well-coated pipe lines.

Field testing of insulating joints and pipe coating resistances is generally done by the voltmeter and ammeter method. A schematic diagram is shown in Figure 8. A 6-volt storage battery or heavy duty dry cells may be used for the source of current. As testing instruments, a suitable low resistance type, multi-range d-c ammeter, range 0.005 to 5.0 ampere, and a high resistance d-c voltmeter of the 400,000 ohms-per-volt type, range 1 and 5 volts, have been found satisfactory.

For testing insulating joint resistance the source of current with the ammeter in series is connected to the test leads installed on each side of the insulating joint. To the same test leads is connected the high resistance voltmeter.

For testing pipe coating resistance the source of current with the ammeter in series is connected between the coated pipe, using one of the above test leads and a water main or other grounded structure.

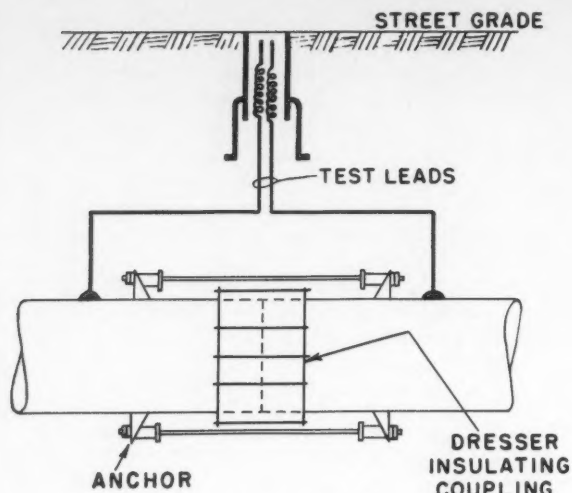


Figure 7—Insulating joint and test station installation.

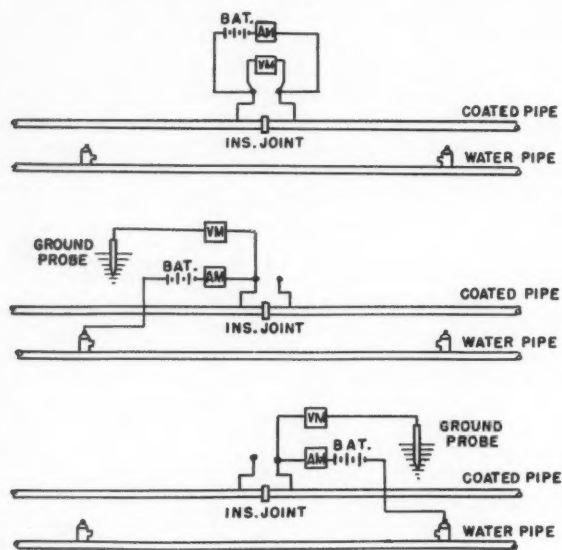


Figure 8

The high resistance voltmeter is connected between the coated pipe, using the above test lead and a ground probe. This ground probe consists of an iron rod wrapped in wet cloth and inserted in a bar hole made for this purpose some 50 to 100 feet from the pipe under test and on the opposite side with respect to the water main or ground structure location. The wet cloth improves the soil contact and reduces probe polarization and possible contact with cinders or other undesirable elements. The probe location on the opposite side of the ground structure prevents any probable test current interference and provides for more uniform pipe-to-soil potentials.

The voltmeter and ammeter are to be read simul-

Hudson River	1	2	3	4	5	6	Harlem River
230'	380'	460'	3840'	2280'	2120'	110'	
MEASURED RESISTANCES							
INS. JOINT	29	70	51	85	25.5	35	19
PIPE COATING	0.005	59	51	8	18.5	17.5	2.5
CALCULATED RESISTANCES							
INS. JOINT	58	291	202	255.5	647	87	
PIPE COATING	0.005	59	31.7	607	67.5	8.25	19.7
CORRECTED COATING RESISTANCES							
PIPE COATING	0.005	69.5	70.0	65.5	65.0	8.5	20.0
OHMS PER 1000 FEET							
PIPE COATING	0.0015	24.5	39.0	27.6	45.6	48.0	5.1
OHMS PER SQUARE FOOT							
PIPE COATING	9.1	194,000	308,000	218,000	360,000	380,000	24,500

Figure 9—Insulating joint and pipe coating resistance, 30-inch natural gas pipe line, Manhattan, N. Y.

taneously and with the current source connected direct and reversed to correct for possible normal current or potential on the pipe line. One-half of the algebraic difference of the two potential and current readings should be used in computing the resistance.

The field measurements must be made with sufficient accuracy and precision so that the tested resistance values A, B and C form a triangle or that the sum of any two of them is always greater than the third.

Since the coating resistance of a given section is usually measured at each end of the section, two values of resistances are obtained which may not be exactly alike, due to an IR drop along the pipe caused by the test current through the adjacent insulating joint. The average of these values should be used in the computations for the true resistance.

If the pipe line is provided with cathodic protection, this equipment must be disconnected from the pipe a few days previous to the test in order that the pipe line may depolarize and the resistance becomes stable.

The table shown in Figure 9 gives the results of a survey made along a 30-inch coated steel pipe line having a number of insulating joints. This table shows the field tested resistances, the computed resistances and the corrected resistances of all joints and pipe coating.

It is to be noted that the computed resistances of the insulating joints are considerably higher and of the pipe coatings somewhat higher than the measured resistances. This shows that joint and coating resistances are always higher than the tested values indicate. However, if the joint and coating resistances have to meet certain specified limits, the tested values may fail to meet these limits.

In conclusion, this method of determining pipe coating and insulating joint resistances has been adopted in the New York City area and has been found quite satisfactory and easily workable.

Hydrogen Blistering of Steel In Hydrogen Sulfide Solutions*

T. SKEI,¹ A. WACHTER,¹ W. A. BONNER² and H. D. BURNHAM³

CORROSION of steel by aqueous hydrogen sulfide has caused extensive damage to refinery equipment of gas compression and fractionation units associated with cracking units and has necessitated more frequent shutdowns and vessel replacement. Damage has resulted from transmission of corrosion-generated hydrogen through steel rather than from wastage of metal, and has been observed in the form of blisters, fissures and temporary embrittlement. Although blistering of steel in sour crude and gasoline service has been observed to a slight extent in the past, it became a serious operating problem about three years ago, presumably as a result of certain changes in operation of catalytic cracking units.

A simplified description of the steps leading to hydrogen damage is represented schematically in Figure 1. Aqueous hydrogen sulfide attacks the steel wall of a vessel, forming atomic hydrogen which normally would combine at the metal surface to form molecular hydrogen. However, in the presence of iron sulfide this recombination is partially poisoned, and a large portion of the hydrogen formed in the corrosion process passes into the steel as atomic hydrogen or protons. While much of this hydrogen passes completely through the steel to form molecular hydrogen at the opposite surface, some encounters a discontinuity or inclusion in the steel and combines at this internal surface to form trapped molecular hydrogen. Since the equilibrium for this reaction predominantly favors molecular hydrogen, which has negligible solubility in steel, this results in a blister when the quantity of trapped hydrogen becomes sufficiently large. Photographs of the surface of a blistered vessel and a section of a blistered plate are shown in Figures 2 and 3. Such conditions have been found in many vessels, but variations in blister location are observed depending on differences in steel within a given vessel and on local differences in environmental conditions. Blistering is found on either wall of a vessel, at all depths in the wall and in sizes ranging from $\frac{1}{32}$ of an inch in diameter to an occasional blister several feet in diameter.

Estimates of the amount of hydrogen required to form a blister in steel plate indicate that relatively small volumes of hydrogen can cause extensive dam-

Abstract

Extensive damage to some refinery equipment has occurred owing to transmission through steel of the hydrogen formed during corrosion of steel by hydrogen sulfide solutions. Damage in the form of hydrogen blistering, fissuring and embrittlement of steel has been particularly severe in catalytic cracking gas plants. Laboratory investigations have been made of the relative influence of environmental factors on the rate and extent of hydrogen transmission through carbon steel. These studies include determination of the effects of concentration of important constituents such as hydrogen sulfide, low molecular weight organic acids, ammonia and hydrogen cyanide. Several other compounds were studied and found to be of minor importance. The laboratory method involved measurement of the volume of hydrogen which passed through to the opposite side of a thin wall of carbon steel. In certain hydrogen sulfide environments hydrogen transmission practically ceased after a short time. This behavior is ascribed to formation of a protective scale of iron sulfide. However, in certain alkaline solutions containing cyanide ion corrosion and a high continuing rate of hydrogen transmission occurred owing to formation of a ferrocyanide complex which prevented development of a protective scale. On the basis of the data obtained it is shown that rate of hydrogen transmission can be reduced greatly by indicated changes in chemical environment.

age. The following assumptions were made as a basis for these calculations:

- 1) a thin cavity exists in the steel plate,
- 2) all hydrogen reaching this cavity is converted to molecular hydrogen,
- 3) the edges of the cavity are rigidly held,
- 4) yield strength of 50,000 psi,
- 5) the initial yield strength does not change as blistering progresses, and
- 6) the blister has the shape of a slice of a sphere.

Thus, to raise a blister one inch in diameter to a height of $\frac{1}{16}$ -inch requires penetration of 100 ml of hydrogen (NTP) per square inch when the cavity is $\frac{1}{4}$ -inch from the steel surface. At a depth of $\frac{1}{8}$ -inch the volume required is 50 ml and for $\frac{1}{16}$ -inch the volume required is 25 ml. These values indicate roughly the extent of hydrogen transmission probably involved in raising steel blisters.

Laboratory investigation was initiated to determine the influence of various possible components of the process streams in promoting hydrogen blistering and thereby provide an explanation for the abrupt increase in hydrogen blistering difficulties experienced as well as indicate remedial measures.

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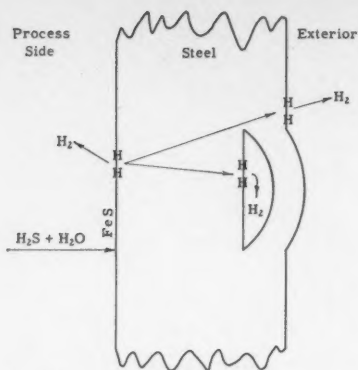


Figure 1—Schematic representation of hydrogen blistering mechanism.

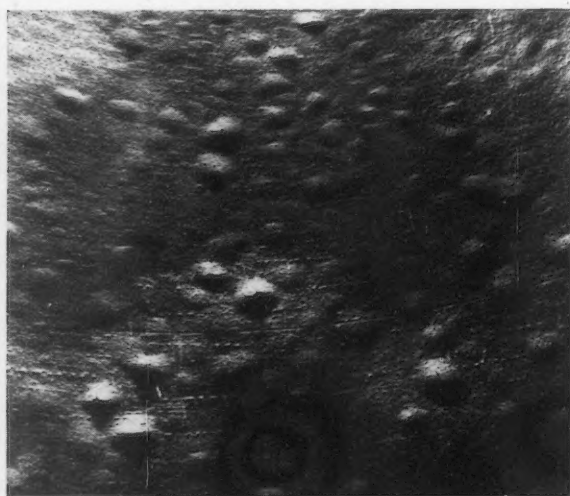


Figure 2—Blistered interior surface of refinery vessel.

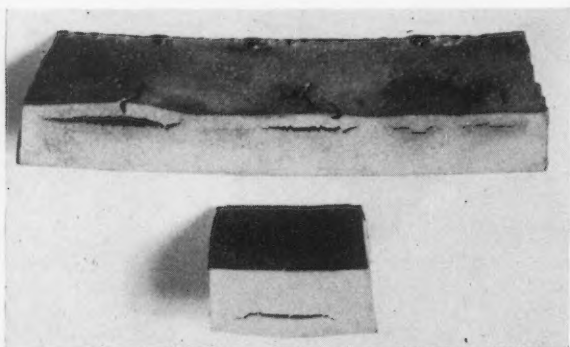


Figure 3—Section of blistered steel plates. Blisters observed between rim and core areas on process and exterior surfaces.

Emphasis was placed on determining the effect of individual pure chemicals on hydrogen transmission through steel exposed to simple environments. Known major components of these streams excluding hydrocarbons include: hydrogen sulfide, carbon dioxide, ammonia and water. The following materials have been observed either occasionally or in lesser amounts: carbon monoxide, nitrogen, oxygen, carbon disulfide,

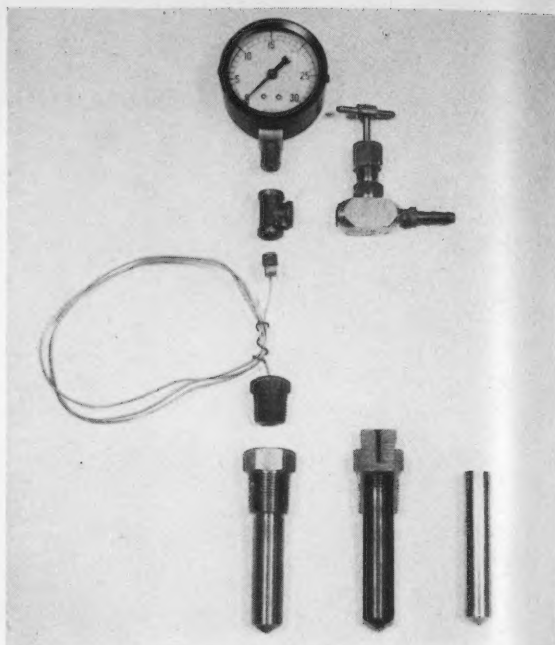


Figure 4—Steel capsule for measurement of hydrogen transmission. Exploded view shows capsule with threaded section allowing use in process equipment. Thin wall section: Area 6.7 sq. in.; OD, 0.785-inch; length, 2.5 inches. Capsule machined from 1¼-inch free-machining low-carbon cold-rolled steel. Total volume of assembly was 9 ml. Capsules were pressure tested for leaks for 48 hours with hydrogen, 900 ml of solution used for each test equivalent to 75 ml per square inch of metal surface.

hydrogen cyanide, methyl mercaptan. Still other components may be present in extremely small quantities or have resisted analysis.

Solution of the hydrogen blistering problem by use of special alloys or linings was considered an undesirable alternative in view of the large investment in existing plant equipment. In addition there was strong indication that a promoter chemical was responsible for the extensive damage observed and that an economic solution would be reached by studying hydrogen transmission through steel as a function of environment.

A general survey of the hydrogen blistering problem was presented recently by R. T. Effinger, et al¹ at the American Petroleum Institute 1951 Mid-year Division of Refining meeting.

The effect of environment on hydrogen blistering is quite complex and was solved by the coordinated efforts of several groups within the Shell organization. This paper reports results from experimental work conducted in the laboratories of Shell Development Company.

Measurement of Hydrogen Transmission

Transmission of hydrogen through steel in aqueous hydrogen sulfide environments was measured by placing a hollow steel capsule in the test solution and recording the volume of hydrogen collected inside the capsule as a function of time. A typical capsule used in laboratory studies is shown in Figure 4. A cut-away section of a capsule in Figure 4 shows the thin wall of steel and the steel filler used to reduce



Figure 5—Apparatus for measurement of hydrogen transmission through plates. Exploded view showing industrial glass section, neoprene gasket, 5/4-inch diameter steel plate of selected material and thickness, neoprene gasket, blind flange with capillary tubing outlet to pressure gauge and bleed valve. Area of plate contacted by solution was 12.0 sq. in. Volume of hydrogen trap was 36.7 ml and 75 ml of solution was used for each square inch of exposed metal.

volume and thereby increase sensitivity of hydrogen volume measurements. Studies with flat plates of steel of varying thickness and with alloy plates were made with the equipment shown in Figure 5. Results with capsules and plates were in good agreement. Since manipulations were simpler with capsules, they were used for the majority of tests. The capsules had a 0.020-inch wall thickness and were machined from cold-rolled hexagonal steel bars. Microstructure was consistent with that of a hot-rolled, free-machining grade of low carbon steel.

Preliminary studies were made by measurement of embrittlement caused by hydrogen in steel, but this method was quickly discarded as insensitive to changes in chemical environment and misleading with regard to effects of exposure time.

The usual procedure employed in studying the effect of environment on hydrogen transmission involved the general procedure described below. Sulfide residues from previous studies were removed from the surface of the capsule by cleaning in dilute hydrochloric acid, followed by neutralizing with bi-

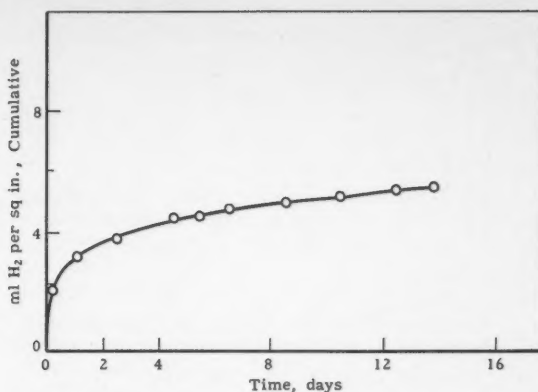


Figure 6—Cumulative hydrogen transmission through steel in aqueous hydrogen sulfide solution. Conditions: Steel capsule, distilled water, one atmosphere hydrogen sulfide, 40 degrees C.

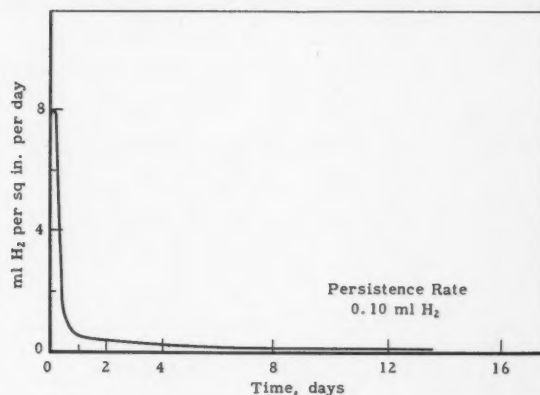


Figure 7. Hydrogen transmission rate through steel in aqueous hydrogen sulfide solution. Derived from data in Figure 6.

carbonate, thorough rinsing with distilled water and drying in acetone. The cleaned capsule was then placed in an aqueous solution in a glass container (75 ml solution per square inch of metal surface) maintained at 40 degrees C and saturated with hydrogen sulfide at one atmosphere pressure. Changes in pressure within the capsule were recorded frequently, converted to volume of hydrogen and plotted as a function of time.

Transmission of Hydrogen Through Steel in Aqueous Hydrogen Sulfide Solutions

A typical study of transmission of hydrogen through the walls of a freshly cleaned capsule immersed in distilled water saturated with hydrogen sulfide is shown in Figures 6 and 7. Initially the passage of hydrogen was very high, but in less than one day exposure the rate of hydrogen transmission decreased markedly and further passage of hydrogen was very slight; presumably the decrease in rate was caused by formation of an adherent coating of iron sulfide which protected the steel from further corrosive attack.

The total quantity of hydrogen passing through the wall of the capsule is plotted in Figure 6 as ml hydrogen per square inch versus time in days. The rate of hydrogen transmission is shown in Figure 7 as ml of hydrogen per square inch per day versus time. Since curves of

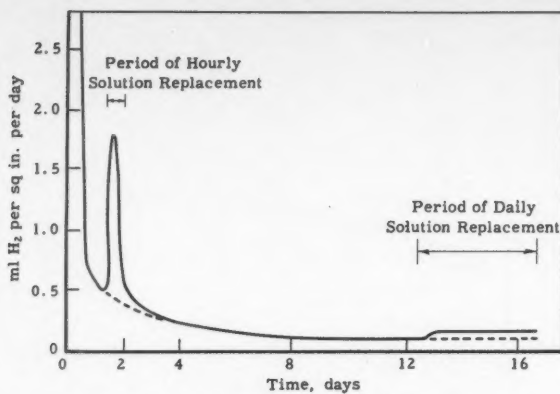


Figure 8—Effect of solution replacement on hydrogen transmission rate through steel in aqueous hydrogen sulfide solution. Dotted lines are reference for no solution replacement (Figure 6). Conditions: Steel capsule, distilled water, one atmosphere hydrogen sulfide, 40 degrees C. Eight hourly replacements of solution in period indicated. Daily solution replacement on 13, 14, 15 and 16 days.

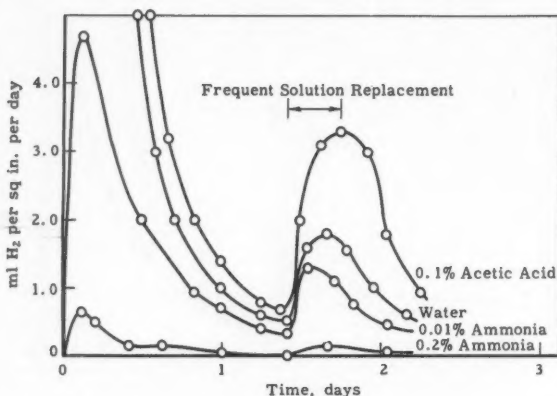


Figure 9—Hydrogen transmission rates for frequent solution replacement in aqueous hydrogen sulfide system. Conditions: Steel capsule, solutions as indicated, one atmosphere hydrogen sulfide, 40 degrees C. Eight hourly replacements of solution during period indicated.

these types will be employed throughout this paper, a brief description follows of the terminology used to describe their characteristics. The *cumulative transmission value*, i.e., total quantity of hydrogen transmitted per square inch, obtained in a test of given duration is considered to be a measure of the blistering tendency of the solution for that test period. However, to assist in extrapolating results of relatively short-term tests, i.e., a few days to 3 weeks, to the long time periods, i.e., one year, which are of practical interest, it is convenient to use the term, *persistence transmission rate*, which is the transmission rate (ml hydrogen per square inch per day) obtained after the transmission rate has leveled off to a reasonably steady value; this may require 5 to 10 days exposure. In the following discussion mention will be made also of the term, *maximum transmission rate*, which is the rate of hydrogen transmission through the capsule during its most active period. This value can be considered to be an indication of the maximum degree of hydrogen embrittlement which might occur.

In this particular case, distilled water saturated with hydrogen sulfide, the cumulative transmission

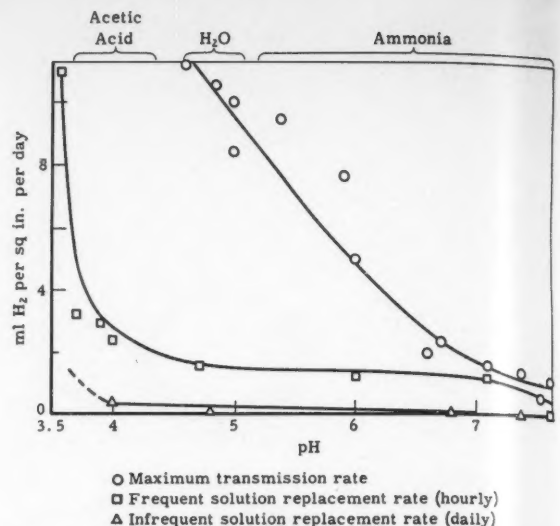


Figure 10—Relationship between pH and rate of hydrogen transmission. Conditions: Steel capsule, one atmosphere hydrogen sulfide, 40 degrees C, pH determined on solutions at end of tests. Solutions used in tests included 0.1 percent formic acid, 0.1 percent acetic acid, distilled water and various concentrations of ammonia.

of 5 ml of hydrogen per square inch is not very large.

After eight days' immersion the persistence transmission rate was 0.10 ml per square inch per day as shown in the last half of Figure 7. This value would not be expected to lead to serious blistering, which is in good agreement with most plant experience in such an environment.

The maximum transmission rate was eight ml of hydrogen per square inch per day, but this high rate was maintained for only the first few hours of test. This value is sufficiently high to lead to pronounced embrittlement during this period, but the embrittlement effects should decline fairly quickly with time because the amount of hydrogen in the steel decreases as the rate of hydrogen transmitted decreases. This is in agreement with laboratory experience wherein pronounced embrittlement effects have been noted in one-day tests in this environment, but only slight effects noted in three-day tests.

Effect of Solution Replacement

An obvious variable in operation is frequency of solution replacement. In certain equipment such as a wash tower, replacement of water is continuous with once-through flow. The reactivating effect of frequent solution replacement is shown in Figure 8 for a study in which the entire aqueous hydrogen sulfide solution was replaced hourly during an 8-hour period.

There are other vessels in which solution replacement would be infrequent. In the latter part of the curve shown in Figure 8 for the period 13 to 17 days, there is a slight rise in transmission rate resulting from daily replacement of solution.

These variations in test procedure were employed in the study of important variables. The test involving hourly replacement over an 8-hour period is termed *frequent solution replacement*, and its effect on

transmission rate should be applicable to those locations, such as a wash tower, where continuous, once-through flow of the aqueous phase occurs. The test wherein solution is replaced daily over a period of several days is termed *infrequent solution replacement* and persistence rates thus obtained would be applicable to those locations where water remains on vessel walls for a more extended time period. The latter condition is considered to apply to the majority of vessels involved in the hydrogen blistering problem.

Effect of pH

The coating of iron sulfide formed during exposure of steel to aqueous hydrogen sulfide is soluble in strong acid. Accordingly, increased corrosion and hydrogen transmission would be expected when pH of the solution is decreased. Results obtained with a 0.10 percent acetic acid solution saturated with hydrogen sulfide demonstrate that hydrogen transmission occurs at a slightly higher rate than with water saturated with hydrogen sulfide.

Since ferrous sulfide is more soluble in the lower pH solution with acetic acid present, solution replacement has a greater effect than found with distilled water. Correspondingly, when the pH of the solution was increased by the presence of ammonia, lower rates were observed. Results are shown in Figure 9 for frequent (hourly) solution replacement experiments with hydrogen sulfide solutions of 0.1 percent acetic acid, distilled water, 0.01 percent ammonia and 0.21 percent ammonia.

From a large number of such studies, relationships between pH and transmission rates were derived as shown in Figure 10 for maximum transmission rate, frequent replacement rate and infrequent replacement rate. At very low pH values ferrous sulfide was completely soluble, the steel remained bright, and there was no difference between initial and frequent replacement rate.

Effect of Temperature

The temperature used most in this investigation was 40 degrees C (105 degrees F), an average temperature for many of the equipment items involved. Cumulative hydrogen transmission values for several other temperatures (0 to 80 degrees C) indicated that temperature was a secondary variable with water saturated with hydrogen sulfide. Although the initial transmission increased markedly with increasing temperature, there was very little difference in persistence rates.

Effect of Pressure

Partial pressure of hydrogen sulfide in the range of 15 to 760 mm had negligible effect on total transmission or on the persistence rate of hydrogen transmission for water saturated with hydrogen sulfide; however, initial rates were higher with the higher hydrogen sulfide concentrations. Nitrogen was used as the inert diluent in these tests.

Effect of Steel Thickness on Hydrogen Transmission

The effect of plate thickness on the rate and extent of hydrogen transmission was determined using 5.25-

inch diameter plates machined from 1-inch thick hot-rolled steel plate corresponding to ASTM Specification A285. A photograph of the apparatus used is shown in Figure 5. Hydrogen transmission studies with flat plates should simulate conditions in a refinery vessel more closely than a capsule since the latter has a small radius of curvature and is convex. Although some differences in behavior were observed with the plate tests in comparison to capsule experiments, these appeared to be mainly in magnitude and not of kind; accordingly, capsules were used in most studies because manipulations were easier.

Transmission rates of hydrogen through plates of 20, 40, 95, and 200 mils (0.200-inch) thickness are shown in Figure 11 for immersion in 0.1 percent acetic acid saturated with hydrogen sulfide. Considerably more hydrogen passed through the thinner plates but the rate was not inversely proportional to thickness. In the example cited the ratio of the transmission rate for the 20 mil plate to the rate of the 200 mil plate was slightly under 4 after one day exposure and slightly over 2 after 4 days exposure.

Thickness transmission relationships for a large number of comparable experiments with a 200-mil plate and a 20-mil plate showed that the relationship is not constant and the ratio of transmission decreased from about 5 to about 2 as activity decreased to low hydrogen transmission rates. This ratio should have had a constant value of 10 if ratios of hydrogen transmission were inversely proportional to thickness. Extrapolated to field conditions the low ratio means that at low activity comparable amounts of hydrogen will pass through both thick wall vessels and thin wall capsules.

Accelerated Hydrogen Transmission Through Steel

Results shown earlier in this paper confirmed previous estimates that insufficient hydrogen transmission occurs in simple hydrogen sulfide solutions to cause appreciable blistering. The plant observation that extensive damage occurred in relatively short time periods in equipment processing small amounts of neutral as well as alkaline sulfide solutions indicated that additional components were responsible for continuous hydrogen transmission. Accordingly, comparison was made of aqueous solutions containing hydrogen sulfide and ammonia with and without additional components such as hydrogen cyanide, carbon monoxide, carbon dioxide and oxygen.

The following types of sulfide solutions were found to promote extensive hydrogen transmission:

- 1) alkaline cyanide, and
- 2) oxygen in acidic and in weakly alkaline solutions.

Carbon monoxide and carbon dioxide were found to have no accelerating effect on hydrogen transmission.

Effect of Ammonium Cyanide

In considering compounds likely to promote hydrogen transmission, particular attention was given to hydrogen cyanide since

- 1) this material was found in catalytically cracked gas streams, and

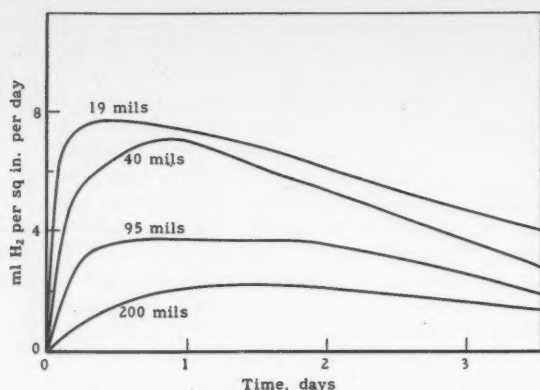


Figure 11—Hydrogen transmission rates through steel plates in aqueous acetic acid, hydrogen sulfide solution. Conditions: ASTM Specification A-285 machined steel plates of indicated thickness, 0.1 percent acetic acid, one atmosphere hydrogen sulfide, 40 degrees C.

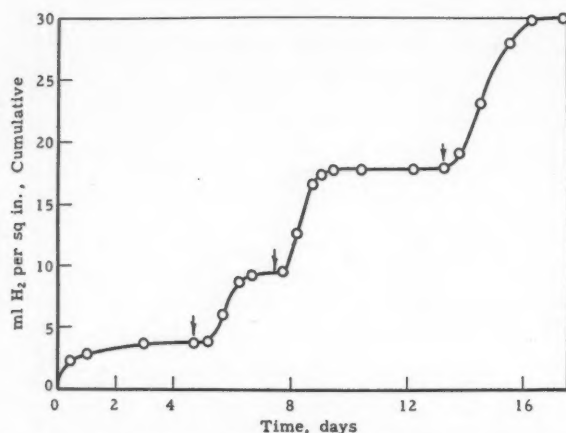


Figure 12—Promotion by ammonium cyanide of hydrogen transmission through steel in aqueous hydrogen sulfide solution. Conditions: Steel capsule, one atmosphere hydrogen sulfide, 40 degrees C. Initial solution, distilled water. Replacement solutions, 2.2 percent ammonium cyanide. Three solution replacements at indicated points.

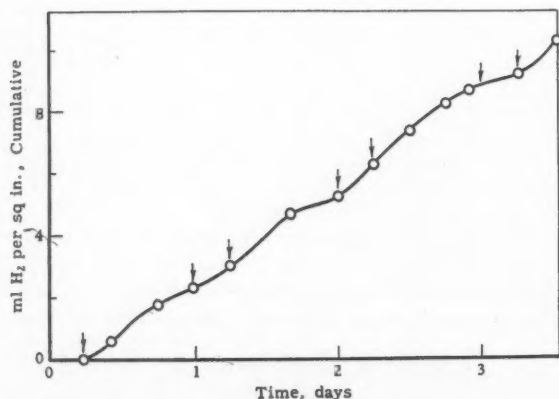


Figure 13—Continuous hydrogen transmission through steel in contact with alkaline cyanide, hydrogen sulfide solution. Conditions: Steel capsule, 0.17 percent hydrogen cyanide—0.85 percent ammonia, one atmosphere hydrogen sulfide, 40 degrees C. Solutions replaced twice daily at indicated points.

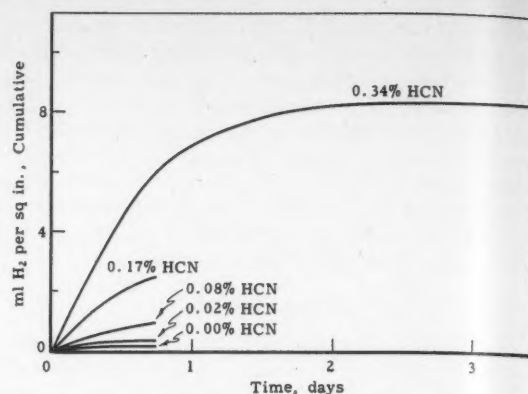


Figure 14—Effect of cyanide concentration on hydrogen transmission through steel in alkaline sulfide solutions. Conditions: Steel capsule, 0.85 percent ammonia plus amount of hydrogen cyanide indicated, one atmosphere hydrogen sulfide, 40 degrees C. Final pH of solutions, 8.0 ± 0.2 .

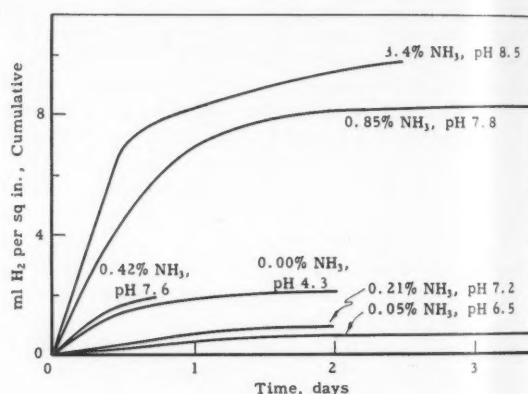


Figure 15—Effect of ammonia concentration on hydrogen transmission through steel in cyanide, sulfide solutions. Conditions: Steel capsule, 0.34 percent hydrogen cyanide and ammonia concentration as indicated, one atmosphere hydrogen sulfide, 40 degrees C. pH at end of test as indicated.

- 2) iron cyanide complexes had been found in water drainings and sludge from several blistered vessels.

Also the occurrence of severe blistering coincided with an increase in cyanide content of the cracked gas streams.

The procedure for screening compounds for promoter activity involved making a regular experiment with aqueous hydrogen sulfide and after a very low rate of hydrogen transmission had been reached, the capsule was exposed to a fresh solution containing the added compound. For example, a solution saturated with hydrogen sulfide and containing 1.35 percent hydrogen cyanide was tested in this manner with no change found in the rate or total hydrogen passage after 40 hours exposure in the presence of cyanide. However, when the replacement solution contained the same amount of cyanide in the form of ammonium cyanide, it was found that marked reactivation occurred as shown in Figure 12. This experiment was composed of several parts which indicate

the mechanism of promotion by cyanide. Thus after 5 days in distilled water saturated with hydrogen sulfide, the capsule was heavily coated with iron sulfide and the rate of transmission was low but not zero. This solution was then replaced with a 2.2 percent ammonium cyanide solution saturated with hydrogen sulfide. Hydrogen passage ceased entirely during the first 12 hours of contact, but during the succeeding day extensive hydrogen transmission occurred. The initial decrease was attributed to reduction in activity at the higher pH, but after the cyanide had dissolved a portion of the protective iron sulfide coating, corrosion occurred with corrosion product being removed as the soluble ferrocyanide ion. The cyanide was consumed after several days exposure and corrosion again ceased, leaving the capsule mottled with both light and heavy coatings of iron sulfide. When this spent solution was replaced by a fresh solution of ammonium cyanide there was a much thinner coating of corrosion product to dissolve and, accordingly, the lag period prior to high rate of hydrogen transmission was greatly reduced. By the end of this exposure period there was an insignificant amount of the original coating remaining and in the following third replacement period the lag period had essentially vanished.

The role of cyanide in dissolving old corrosion product thereby making the surface available for further corrosion is reflected in the increasing total transmission values in these four periods:

Period	Hydrogen Transmission, ml per square inch
1) H_2S	3.8
2) $H_2S + NH_4CN$	5.6
3) $H_2S + NH_4CN$	8.3
4) $H_2S + NH_4CN$	12.5

The total amount of hydrogen passing through the steel during this entire experiment was 30 ml per square inch which would be adequate to cause blistering in many locations.

Another example of means of obtaining continuous hydrogen transmission is shown in Figure 13 for twice daily replacement of a hydrogen sulfide solution containing 0.30 percent ammonium cyanide. The rate of hydrogen transmission was nearly constant with respect to time indicating that a protective corrosion product was not being formed and that the rate would remain high as long as the steel surface was supplied with water, ammonia, hydrogen cyanide and hydrogen sulfide. In the particular example cited 12 ml of hydrogen had been transmitted in four days, and it estimated that in slightly over a month 100 ml of hydrogen would have passed through the steel. In another test it was found that identical rates of transmission were obtained by hourly replacement as compared to twice daily replacement. On the basis of the above, further testing with ammonium cyanide-hydrogen sulfide solutions was simplified so as to use 6-hour test values; these were considered to be comparable to maximum rates, frequent solution replacement rates and persistence rates under conditions of infrequent solution replacement. Corrosion did not occur with alkaline cyanide solutions in the absence of hydrogen sulfide.

The effect of cyanide concentration in water containing 0.85 percent ammonia saturated with hydrogen sulfide is shown in Figure 14. The effect of ammonia concentration (pH) in a similar system but with a fixed cyanide concentration is shown in Figure 15. Rates of hydrogen transmission were calculated from the 6-hour period showing greatest transmission (usually the first 6 hours).

From a series of concentration-transmission rate experiments cross plots of ammonia concentration and cyanide concentration were made leading to the curves shown in Figure 16 which show the relationship between pH and hydrogen transmission rate for several concentrations of hydrogen cyanide. In the lower pH range the rate values are for frequent solution replacement, whereas at higher pH values it is considered that these values represent both frequent and infrequent solution replacement as long as adequate supplies of hydrogen cyanide and ammonia are available. From this family of curves the rate of transmission under given conditions can be estimated, e.g., at a cyanide concentration of 0.10 percent and pH of 8.0 the transmission rate of hydrogen would be estimated at 5 ml hydrogen per square inch per day. It is also noted that low activity is found below pH 7.5.

pH values were measured at room temperature by cooling the used solutions without contact with air or loss or gain of hydrogen sulfide. Relationships of pH to ammonia concentration for used solutions from experiments at 40 degrees C are shown in Figure 17. These values did not change by more than several tenths of a pH unit during exposure tests, and similar pH values were obtained with or without hydrogen cyanide present when the cyanide concentration did not exceed the ammonia concentration.

Temperature was shown to be a variable of secondary importance. Tests with an alkaline cyanide solution (0.34 percent hydrogen cyanide and 0.85 percent ammonia) saturated with hydrogen sulfide showed an increasing initial rate of hydrogen transmission on increasing the temperature from 25 degrees C to 60 degrees C, but the total amount transmitted was slightly lower at the higher temperature.

Very little difference in hydrogen transmission was observed with an ammonium cyanide solution using a gas stream containing either 25 or 100 percent hydrogen sulfide; the ammonium cyanide solution contained 0.34 percent hydrogen cyanide and 0.85 percent ammonia. Lower transmission was observed at 5 and 2 percent hydrogen sulfide and no passage of hydrogen was observed when the gas stream contained nitrogen only. Lower total transmission observed with 5 and 2 percent hydrogen sulfide (37 and 15 mm Hg partial pressure) may be related to premature consumption of cyanide, e.g., by alkaline hydrolysis or polymerization.

Effect of Oxygen

Since oxygen is present in many refinery streams as a result of air contamination, tests were made on the effect of oxygen in sulfide environment. These showed that oxygen could serve as a promoter of hydrogen transmission in some cases and as an inhibitor in others. The promoting effect was noted in

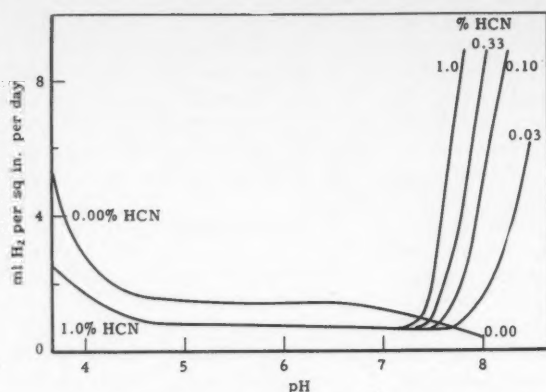


Figure 16—Relationship between pH and rate of hydrogen transmission for several hydrogen cyanide concentrations. Conditions: Steel capsule, one atmosphere hydrogen sulfide, 40 degrees C. Frequent solution replacement rates below pH 7. Infrequent solution replacement rates above pH 7. Solutions used in tests included 0.1 percent formic acid, 0.1 percent acetic acid, distilled water and various concentrations of ammonia.

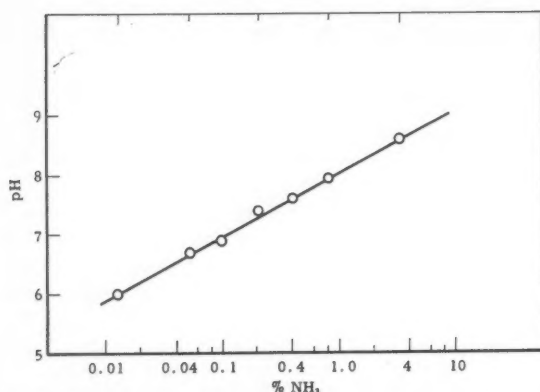


Figure 17—Relationship between pH and ammonia concentration in alkaline cyanide, hydrogen sulfide solutions. Conditions: pH values of used solutions from capsule tests were measured after cooling from 40 degrees C to room temperature in closed containers. Relationship shown applies to solutions with molar ratios of ammonia to hydrogen cyanide greater than one. Hydrogen sulfide pressure, one atmosphere.

the lower pH systems. The inhibition effect was related to the formation of polysulfide ion, which in hydrogen sulfide saturated alkaline cyanide solutions, would prevent corrosion and subsequent hydrogen transmission by reacting with the cyanide to form thiocyanate ion which does not promote hydrogen transmission. Prevention of hydrogen transmission by polysulfide in an alkaline cyanide solution is shown in Figure 18.

Effects of oxygen were determined either:

- 1) by including 2 percent air in the gas stream from the beginning of a test, or
- 2) by allowing the hydrogen transmission rate to reach a fairly constant value prior to introduction of 2 percent air.

The latter test was particularly useful for determin-

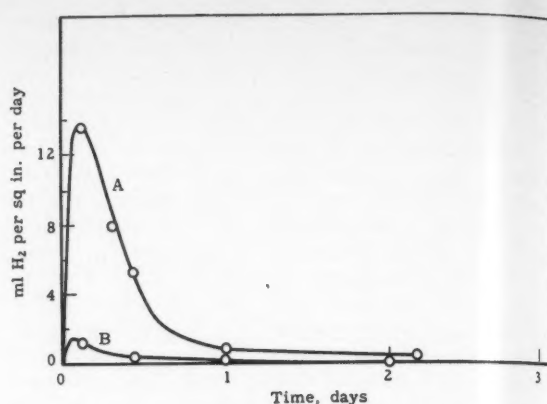


Figure 18—Effect of polysulfide ion in prevention of hydrogen transmission through steel in alkaline cyanide, sulfide solution. Conditions: Steel capsule, 0.34 percent hydrogen cyanide—0.85 percent ammonia, one atmosphere hydrogen sulfide, 40 degrees C. Curve A, no polysulfide. Curve B, 0.9 percent sulfur added as ammonium polysulfide.

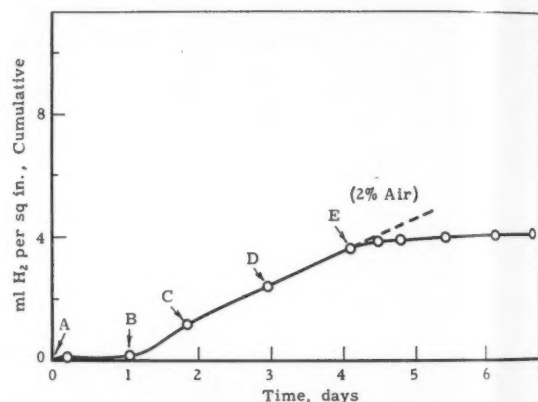


Figure 19—Effect of air in prevention of hydrogen transmission through steel in alkaline cyanide, sulfide solution. Conditions: Steel capsule, one atmosphere hydrogen sulfide, 40 degrees C. Replacement solutions: A, 3.4 percent ammonia. B, C, D, 3.4 percent ammonia—0.03 percent hydrogen cyanide. E, 3.4 percent ammonia—0.03 percent hydrogen cyanide treated with hydrogen sulfide containing 2 percent air.

ing the harmful effects of air in low pH systems. Both procedures were used in studying prevention of hydrogen transmission in alkaline cyanide solutions. Here it was found that no transmission of hydrogen occurred if air were present initially; if air were added to the system after a steady rate of transmission had been obtained, the rate dropped to a negligible value within one day. Effectiveness of 2 percent air in prevention of hydrogen transmission is shown in Figure 19 for the sulfide solution containing 3.4 percent ammonia and 0.03 percent hydrogen cyanide after a continuous rate of transmission had been obtained by a series of daily replacements of solution.

Effects of air on hydrogen transmission in the slightly alkaline, neutral and acid zones were investigated by observing the effect of air on hydrogen passage after establishment of the persistence rate in

the absence of air. Cumulative hydrogen transmission results for a series of tests in the pH range of 4.0 to 7.6 are shown in Figure 20. The corrosive effect of air in causing increased hydrogen transmission is quite marked in the lower pH ranges, but essentially disappears between pH 7.5 and 8.0 in which range air changes to an inhibitor of the alkaline cyanide promoted reaction by causing formation of polysulfide ions.

Air was without effect on persistence rate of hydrogen transmission in neutral-slightly alkaline solutions (pH 7.6); presence of small amounts of hydrogen cyanide was without effect in such solutions. It is believed that the corrosive effect of air is independent of small amounts of hydrogen cyanide present in acid or neutral sulfide solutions. Persistence rates with 2 percent air present are shown in Figure 21 as a function of pH.

Prevention of Hydrogen Blistering By Use of Selected Carbon Steels

Prevention of hydrogen damage was considered possible by use of particularly clean steels which might allow transmission of hydrogen through steel without blistering or fissuring damage. Screening tests were made with polished strips of various carbon steels immersed in 0.1 acetic acid saturated with hydrogen sulfide and in alkaline cyanide solution (0.34 percent hydrogen cyanide, 0.85 percent ammonia) saturated with hydrogen sulfide. All of the strips stored in acid sulfide solution were blistered and most of the strips stored in alkaline cyanide were blistered, but to a lesser extent. Presumably more blistering would have occurred in the latter solution if a higher concentration of cyanide had been employed. Corrosion rates (by weight loss) of 20 to 30 mils per year were observed in the acid sulfide system and of 4 to 6 mils per year in the alkaline cyanide-sulfide solution after one week at room temperature. The steels tested included cold-rolled low carbon steel (5 stocks), ingot iron, hot-rolled drum steel and enameling steel.

Failure to find complete freedom of blistering in any of the eight carbon steels examined, plus anticipated difficulty of procuring perfectly clean steel, makes this an unattractive approach.

Prevention of Hydrogen Blistering by Use of Alloys

Prevention of hydrogen transmission presumably could be realized by use of alloy materials that are not subject to corrosion or do not transmit hydrogen. Despite the higher cost of such alloys, this approach might be justified in certain locations for critical items and unusually severe conditions. Some promising results were obtained but complete evaluations were not made in view of early indications that the problem could be solved economically by environmental changes.

Screening tests were made in acid sulfide (0.1 percent acetic acid) and alkaline cyanide sulfide (0.34 percent hydrogen cyanide, 0.85 percent ammonia) solutions for one week exposure at room temperature. Several low alloy steels (5 percent Ni steel; 4-6 percent Cr, 0.5 percent Mo steel; 1 percent Cr, 0.5 per-

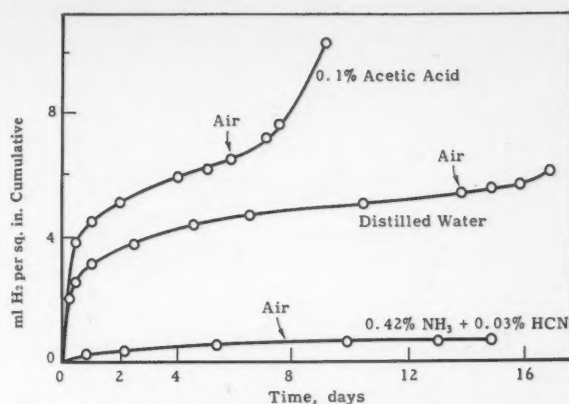


Figure 20—Effect of air on cumulative hydrogen transmission through steel in hydrogen sulfide solutions. Conditions: Steel capsule, solutions as indicated, one atmosphere hydrogen sulfide, 40 degrees C. Atmosphere changed to 98 percent hydrogen sulfide—2 percent air as indicated by arrows.

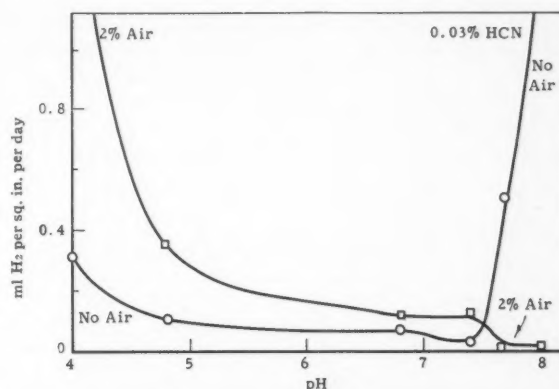


Figure 21—Effect of air on rate of hydrogen transmission through steel in hydrogen sulfide solutions as a function of pH. Conditions: Steel capsule, one atmosphere hydrogen sulfide, 40 degrees C. Below pH 7: Persistence rates of penetration obtained as shown in Figure 20 without and with 2 percent air present; no solution replacement. Above pH 7: Persistence rates of penetration obtained as shown in Figure 19 without and with 2 percent air present; daily replacement of solution containing 0.03 percent hydrogen cyanide.

cent Cu, 1 percent Si steel) suffered blistering. Monel and nickel were corroded at rates of 10 mils per year in alkaline cyanide sulfide solution compared to a rate of 4 to 6 mils per year for carbon steel. Slight pitting was found on Type 302 and 430 stainless steels but the corrosion rate was less than one mil per year and no blistering occurred. No transmission of hydrogen occurred through plates of Monel, nickel, Type 302 or 430 stainless steels in either acid sulfide or alkaline cyanide-sulfide solutions.

Summary of Causes, Prevention and Extent of Hydrogen Transmission as Related to Environment

Understanding obtained in this investigation of the various reactions promoting hydrogen transmission through steel indicates the nature of preventive measures applicable to various situations. Although evidence for some of the reactions given in the following summary may be meager, they are in-

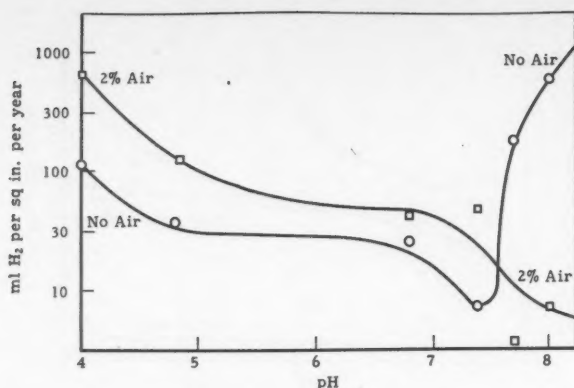
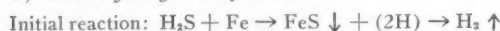


Figure 22—Estimate of yearly transmission of hydrogen through steel. Effect of air, cyanide and pH. Conditions: Steel capsule, solutions of acetic acid, water or ammonia with 0.03 percent hydrogen cyanide as required, one atmosphere hydrogen sulfide with and without 2 percent air, 40 degrees C. Persistence rate results based on data summarized in Table I indicating extent of hydrogen transmission under conditions of persistence with either infrequent or no solution replacement.

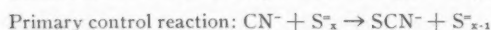
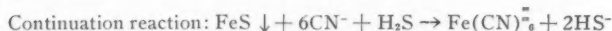
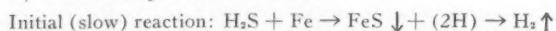
cluded because they contribute to reasonable hypotheses of actions in the light of existing information.

1) Acid hydrogen sulfide reaction.



Hydrogen transmission in acid solutions increases with decreasing pH, with increasing frequency of solution replacement, and with increasing air contamination. Under moderate conditions reaction is self-stifling by formation of an adherent insoluble coating of corrosion product. Control measures include increase of pH as indicated earlier or use of suitable corrosion inhibitors.

2) Alkaline cyanide reaction.



Hydrogen transmission in alkaline solutions containing sulfide and cyanide ions increases with pH and concentration of cyanide. Reaction is most easily controlled by removal of cyanide by stoichiometric reaction with polysulfide ion. Alkaline cyanide activation may be controllable also 1) by decreasing pH, 2) removal by water washing, hydrolysis or by reaction with other materials, or 3) by use of inhibitors other than polysulfide ion.

3) Oxygen reaction.

The hydrogen transmission reaction presumably is the same as involved in the other cases described. The means of obtaining continued hydrogen transmission is not clear, but probably involves prevention of formation as well as destruction of an adherent, protective iron sulfide corrosion coating on steel. Hydrogen transmission was not observed above pH 7.5.

The significant hydrogen transmission data obtained in this study are recapitulated in Tables I and II and Figure 22. In Table I are presented data for hydrogen sulfide solutions containing 0.03 percent hydrogen cyanide covering the pH range 4.0 to 8.5 and in the absence and presence of air. The effects of various quantities of hydrogen cyanide in pH regions showing cyanide promoted activity are listed in Table II. Estimates of volume of hydrogen passing through a steel wall after one year exposure in dilute cyanide solutions

TABLE I. Summary of Hydrogen Transmission Rates

Under conditions of:

- 1) Hydrogen sulfide pressure of 1 atmosphere.
- 2) Adequate supplies of hydrogen cyanide and ammonia to maintain concentrations.
- 3) 40°C.
- 4) Clean and active metal surface at start of tests.
- 5) Steel wall thickness 0.020 inches.

Solution Composition		Hydrogen Transmission Rate, ml. H ₂ per Sq. In. per Day				
		Max.	Frequent Soln. Replacement	Persistence Rate		
				In-frequent Soln. Replacement	Not Replaced	2% Air
pH	Ingredient					
3.6	0.1% formic acid...	16.5	15.2			
4.0	0.1% acetic acid...	11.7	3.2			
4.8	Distilled water...	8.1	1.8	9.15	0.10	0.35
6.0	0.013% ammonia...	4.7	1.3			
6.8	0.10% ammonia...	0.9	0.2		0.07	0.12
7.4	0.21% NH ₃ + 0.03% HCN....	0.6	0.05		0.02	0.13
7.7	0.42% NH ₃ + 0.03% HCN....	0.5	0.5	<0.5		0.01
8.0	0.85% NH ₃ + 0.03% HCN....	1.6	1.6	1.6		0.02
8.5	3.4% NH ₃ + 0.03% HCN....	6.1	6.1	6.1		0.03

TABLE II. Effect of pH and Cyanide Concentration on Hydrogen Transmission Rates

Conditions as in Table I.

Rates are considered applicable to condition of both frequent and infrequent solution replacement.

Solution Composition		Rate, ml H ₂ per Sq. In. per Day			
		Hydrogen Cyanide Concentration, %			
pH	Ingredient	1.0	0.33	0.10	0.03
7.4	0.21% ammonia...	1.0	0.7		
7.5		2.0	1.0	0.6	
7.6		4.0	2.0	0.9	
7.7	0.42% ammonia...	6.0	2.9	1.4	0.5
7.8		8.0	4.2	2.0	0.9
7.9		10.0	6.0	3.2	1.2
8.0	0.85% ammonia...	11.5	7.8	5.0	1.6
8.1		13.0	9.7	6.5	2.0
8.2		15.0	11.4	8.0	2.8
8.3			12.6	9.2	3.8
8.4				10.7	5.0
8.5	3.4% ammonia....			11.8	6.1

with and without air present are shown in Figure 22 as a function of pH. These are plotted on a logarithmic scale in order to show the extreme differences in hydrogen transmission as a function of environment. Values of less than 5 to 10 ml of hydrogen per square inch per year would not be expected to do appreciable damage, whereas extensive blistering would be expected in the range of 50 to 100 ml per square inch per year.

Results presented in this paper indicate an approach which is believed to be practical in obtaining an understanding of environmental factors causing hydrogen blistering. From such studies appropriate means of protection can be devised for various situations.²

Acknowledgment

Appreciation is expressed for the cooperation of several persons who have contributed materially to the progress of this investigation. From the Shell Development Company these include: Miss Rita Wieland for hydrogen embrittlement studies; R. S. Treseder for constructive discussions; E. G. Chilton for calculations of hydrogen volumes required for blistering. From Shell Oil Company these include: R. T. Effinger, M. L. Renquist, and J. G. Wilson.

References

1. R. T. Effinger, M. L. Renquist, A. Wachter and J. G. Wilson. Hydrogen Attack of Steel in Refinery Equipment. *Proc. Amer. Pet. Inst. Mid-Year Meeting*. Section III, Refining, 107-130 (1951) May.
2. Another paper on this subject by Bonner, Burnham, Conradi and Skei has been prepared for presentation at the Division of Refining of the American Petroleum Institute at its meeting May 11-14, 1953 at New York.

Second¹ Interim Report

Publication 53-1

TP-6 G—Surface Preparation for Organic Coatings²Report on Surface Preparation of Steels
For Organic and Other Protective Coatings

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Foreword

THIS report is intended to convey to users of steel, the importance of correct surface preparation for coatings. The various processes available for this purpose are systematically described. A choice among them will be influenced by economic factors and in some cases by the nature of the painting systems, but it should be emphasized that good surface preparation is essential for successful protection by coatings. A correct standard appropriate to each particular job should be established and a worse surface preparation than this should not be tolerated.

The closeness of contact between metal and paint must be borne in mind at all times. The following list shows some of the typical surface conditions

Abstract

This report describes many mechanical and chemical surface preparation processes, conditioners and pretreatments for organic and other coatings that have been used commercially to a greater or lesser extent. Also outlined are good surface preparation practices for galvanized surfaces, maintenance and repair conditioning of surfaces and coatings as well as the assembly of dissimilar metals.

which may be present, and in general, should be removed.

1. Heavy rust
2. Thin adherent rust
3. Loose rust
4. Loose mill scale
5. Tight mill scale
6. Oil (mineral and non-drying)
7. Grease (mineral and non-drying)
8. Preservative Compounds
9. Dirt
10. Paint marks
11. Weld scale, flux, slag
12. Salts in general
13. Drawing Compounds
14. Chalk Marks
15. Moisture
16. Wax
17. Sulphites, imbedded and otherwise
18. Slag inclusions

The extent of removal of these oxides and contaminants depends on the type of coating to be used.

Unless a coating can wet through interferences which may prevent contact between the paint and metal, the surface must be clean and free of any foreign matter and/or other surface contamination. Some film-forming wetting materials have been used advantageously to prewet a limited quantity of these interference products. The compatibility of these materials and the succeeding paints must be considered when writing specifications for their use.

Also included in this report are the surface preparation and pretreatments used for galvanized surfaces. An outline has been made on the assembly of dissimilar metals, on maintenance and repair jobs and the pretreatment of metal with oils and other conditioners.

In addition to the use of this report, it is recommended that the user secure from:

1. American Society for Testing Materials, 1916 Race St., Philadelphia, Pa. Sub-Committee XXIX, Committee D-1—

¹ First Interim Report of this technical committee was published in CORROSION, August, 1950. Second Interim Report dated October, 1952.

² A. J. Liebman, The Dravo Corp., Pittsburgh, chairman.

- "Pictorial Standards on Classifying Ferrous Surfaces for Painting."
2. Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, Pa. "Surface Preparation," "Pretreatment," and "Painting Specifications."
 3. American Welding Society, 33 West 39th St., New York, New York. "Surface Preparations for Metallizing."
 4. National Safety Council, 425 N. Michigan Avenue, Chicago, Ill.—References and Bulletins regarding health and safety precautions for various surface preparation methods listed in this report.
 5. Manufacturing Chemists Association, Woodward Bldg., Washington, D. C.—Information on Safety Measures for Chemical Treatment Operations.

I. Surface Preparation for Steel

A. Surface Oxidation by Weathering

1. This age-old process makes use of natural exposure of steel to the weather to remove the mill scale. The weathering corrodes the steel which undermines and loosens the mill scale, leaving a rusted surface (iron hydroxides). Since it in itself is not a complete method of surface preparation, it is good practice to remove this rust and other contaminants by any of the methods shown in this report, before applying either the inhibitor or primer.

2. Removal of mill scale by weathering will range from removal of only already loose mill scale to complete elimination of the tight scale as well. The extent to which such weathering is required will be determined in part by the nature of the coating to be applied and in part by service requirements.

3. The time required to completely descale a metal by weathering, can vary from 30 days in severe and humid industrial environments, to several years in milder rural environments.

4. If metal weathers and descales in a low humidity atmosphere, the metal loss will be slightly higher than with a surface prepared by blasting. In a corrosive atmosphere or one of high humidity, the losses encompassing the removal of all mill scale can reach approximately three times that of the metal removed by blasting. In these environments, pitting of the metal to various degrees may result from weathering. Once these pits are formed, the metal cannot be economically restored to its original value.

B. Wire Brushing

1. Wire brushing will remove all accessible loose scale and other loose corrosion products and/or some other contaminants, but will not remove all tight mill scale, tight oxide or any imbedded corrosion products.

2. Wire brushing of scale covered steel does not produce an acceptable surface anchor for all protective coatings. A protective coating with good adhesion and wetting characteristics must be used for good end results. Excessive power wire brushing often results in an undesirable burnished (polished) condition of the metal surface, causing a poorer surface anchor for general paints.

3. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed by one of the methods

included in this report for that purpose, prior to wire brushing. Brushes are to be kept clean from these contaminants, otherwise spreading of contaminants will induce early coating failure. (See Surface Cleaning)

Safety Measures—Safety goggles should be worn. Filter type air respirators, forced air supply to the operator and adequate ventilation are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

C. Impact Tool Cleaning

1. The following tools are used by industry in surface preparation work: hand and pneumatic hammers, chisels, scaling tools, scrapers, rotary centrifugal cleaners using a hammer and milling principle.

2. Following impact tool cleaning, the surface must be wire brushed.

3. When impact cleaning tools are used, care must be exercised that the tools are kept suitably sharp. Dull tools will drive the scale and corrosion products into the surface of the metal, thus creating a nucleus for corrosion after the protective coating has been applied. These products are usually so firmly imbedded in the metal that it is impossible to remove them with a wire brush.

4. Oil and grease and other contaminants detrimental to the performance of coatings to be applied, must be removed prior to impact tool cleaning, by one of the methods included in this report for that purpose. (See Surface Cleaning)

Safety Measures—Safety goggles and gloves should be worn. Filter type air respirators, forced air supply to the operator, and adequate ventilation, are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

D. Grinding

Good anchors can be produced by using grinding wheels and sanding disc type power equipment. This method of surface preparation is highly suitable when weld seams, sharp edges and metallic surface imperfections must be smoothed. It provides a good anchor for coatings. However, it is generally more costly than are the several other methods described in this report. Care must be taken in selecting the grit size of wheel and sanding disc. Coarse grit will produce deep grooves in the metal, thus causing insufficient paint coverage at the high points. Care must be exercised in the selection of proper grinding medium and equipment to prevent burnishing (polishing) of the surface, thus causing a poor surface anchor for coatings.

Safety Measures—Safety goggles and gloves should be worn. Filter type air respirators, forced air supply to the operator and adequate ventilation are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

E. Flame Conditioning

1. This method employs an intensely hot, high velocity, brush-like flame that is passed over the metal to be descaled. The heat applied causes the loose and some of the tight mill scale to spall. Most corrosion products are similarly affected. This process has the further advantage that the local heat reduces the moisture film on the metal surface.

2. Immediately after flame conditioning, it is necessary to wire brush the surface before applying any protective coating. Wire brushing will remove partially loose or upturned scale. A clean brush must be used for this work. To obtain the full benefit of this method, the primer or protective coating must be applied to the metal surface while it is still warm, therefore proper timing is essential.

3. Where flame conditioning is used for the removal of moisture only on descaled steel, wire brushing may not be necessary.

4. Extreme care must be exercised on sections lighter than 3/16-inch to prevent any possible warpage from local overheating. Steel plates and shapes can be flame cleaned without causing undue warpage if the metal thickness is greater than 3/16 inch. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed prior to flame conditioning by one of the methods included in this report for that purpose. (See Surface Cleaning)

5. The flame conditioning process is suitable for conditioning of surfaces that have suffered from hydrogen embrittlement. The general procedure requires the removal from the surface of all corrosion, scale and other detrimental products by one of several surface preparation methods. However, blast cleaning is preferred. The clean surface of an embrittled steel may look dark. The passage of a flame or other consequent heating of the metal will cause the hydrogen to escape from the metal. The metal must be heated throughout to a suitably high temperature (200-300 degrees F) to release the hydrogen. It is suggested that this flame treatment operation be followed by a second surface cleaning, again preferably by blast cleaning. Unless the metal has suffered severely, it can be restored to proper usefulness with this combination process. It has also been found advantageous to wash an embrittled surface with warm water thus causing escape of the hydrogen. Here, the metal must be heated throughout to approximately 200 degrees F. However, this method is effective only on surfaces that are not severely attacked.

Safety Measures—Caution: Flame cleaning should not be used if a heavy deposit of iron sulfide is present unless this deposit is first removed by blasting or other suitable surface preparation methods since the sulfur present constitutes a fire hazard.

For use of flame cleaning for the removal of coatings, see Section D, under "Maintenance and Repair Jobs."

Operators must wear safety goggles. Proper precautions must be taken if explosion hazards are present. In enclosed areas, proper ventilation must be provided.

F. Nozzle Blast Cleaning

1. Open Dry System

1.1. This system employs near uniform grain size abrasive particles which are discharged through a nozzle outlet of specific size at a predetermined pressure, thus creating an abrasive particle velocity which produces sufficient impact and abrasion to remove mill scale, corrosion and other undesirable products from steel, before protective coatings are applied.

1.2. The commercial cleaning rate of air blast on steel sheets and plates using a 3/8 inch diameter nozzle and 90-lb. air pressure will average from 3 to 6 sq. ft. per minute, depending on the degree of cleanliness required, abrasive particle size and type and nature and thickness of scale on the steel. This nozzle would deliver approximately 72 lb. of abrasive (metallic) per minute and require about 36 HP. An average cleaning figure would be about .125 sq. ft. per minute per horsepower.

1.3. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed prior to blasting, by one of the methods included in this report for that purpose. Brushes are to be kept clean from these contaminants, otherwise spreading of contaminants will induce early coating failure. (See Surface Cleaning)

1.4. In order to reduce the health hazard caused by a high percentage breakdown of the blast abrasive, the selection of a very clean and hard abrasive becomes extremely important. The scale, rust and other products removed from steel will produce an uncontrollable quantity of dust and waste. If it is at all possible, good blast abrasive should be reclaimed and reused until a maximum abrasive particle breakdown makes its further reclaiming uneconomical. Avoid contamination of reclaimed abrasives.

Safety Measures—All blasting equipment must be grounded to prevent shock from static electricity.

2. Cabinet Blasting

2.1. The aforesaid description of equipment and results as outlined under the Open Dry System is also applicable to a ventilated cabinet blasting system.

2.2. In fully enclosed cabinets, the operator handles the blast nozzle from the outside through a shielded opening in the cabinet. Safety helmets and air supply to the operator can be omitted in this operation. Safety goggles and gloves should be worn. The cabinet and blasting equipment should be properly grounded. The use of a light reflecting paint on the inside will help vision during operation.

3. Closed Recirculating System

3.1. In addition to the conventional open systems, there are also available closed portable systems which employ the continuous recirculating method.

3.2. The continuous system uses synthetic abrasives or steel grit and shot. While sand can be used with this system, its breakdown rate will require a too frequent recharging.

3.3. The abrasive is discharged from the blast nozzle in the same manner as outlined in Paragraph 1 on the Open Dry System of blasting. However, the nozzle is enclosed, permitting recovery of the grit immediately upon impingement of the surface. A brush is mounted to the enclosure and acts as the surface sealer. The abrasive is returned to the blast tank through a large hose, is cleaned and recirculated until it disintegrates. Separate suction is required for the recirculation process.

3.4. For angles, frames pipes and other shapes, brush shapes and cup enclosures must conform to the shape of the work. The adoption of this type of equipment should be carefully studied as its limitations permit use only under certain conditions.

- "Pictorial Standards on Classifying Ferrous Surfaces for Painting."
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B. Wire Brushing

1. Wire brushing will remove all accessible loose scale and other loose corrosion products and/or some other contaminants, but will not remove all tight mill scale, tight oxide or any imbedded corrosion products.

2. Wire brushing of scale covered steel does not produce an acceptable surface anchor for all protective coatings. A protective coating with good adhesion and wetting characteristics must be used for good end results. Excessive power wire brushing often results in an undesirable burnished (polished) condition of the metal surface, causing a poorer surface anchor for general paints.

3. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed by one of the methods

included in this report for that purpose, prior to wire brushing. Brushes are to be kept clean from these contaminants, otherwise spreading of contaminants will induce early coating failure. (See Surface Cleaning)

Safety Measures—Safety goggles should be worn. Filter type air respirators, forced air supply to the operator and adequate ventilation are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

C. Impact Tool Cleaning

1. The following tools are used by industry in surface preparation work: hand and pneumatic hammers, chisels, scaling tools, scrapers, rotary centrifugal cleaners using a hammer and milling principle.

2. Following impact tool cleaning, the surface must be wire brushed.

3. When impact cleaning tools are used, care must be exercised that the tools are kept suitably sharp. Dull tools will drive the scale and corrosion products into the surface of the metal, thus creating a nucleus for corrosion after the protective coating has been applied. These products are usually so firmly imbedded in the metal that it is impossible to remove them with a wire brush.

4. Oil and grease and other contaminants detrimental to the performance of coatings to be applied, must be removed prior to impact tool cleaning, by one of the methods included in this report for that purpose. (See Surface Cleaning)

Safety Measures—Safety goggles and gloves should be worn. Filter type air respirators, forced air supply to the operator, and adequate ventilation, are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

D. Grinding

Good anchors can be produced by using grinding wheels and sanding disc type power equipment. This method of surface preparation is highly suitable when weld seams, sharp edges and metallic surface imperfections must be smoothed. It provides a good anchor for coatings. However, it is generally more costly than are the several other methods described in this report. Care must be taken in selecting the grit size of wheel and sanding disc. Coarse grit will produce deep grooves in the metal, thus causing insufficient paint coverage at the high points. Care must be exercised in the selection of proper grinding medium and equipment to prevent burnishing (polishing) of the surface, thus causing a poor surface anchor for coatings.

Safety Measures—Safety goggles and gloves should be worn. Filter type air respirators, forced air supply to the operator and adequate ventilation are recommended where dust is present. When working around flammable materials, non-sparking tools must be used.

E. Flame Conditioning

1. This method employs an intensely hot, high velocity, brush-like flame that is passed over the metal to be descaled. The heat applied causes the loose and some of the tight mill scale to spall. Most corrosion products are similarly affected. This process has the further advantage that the local heat reduces the moisture film on the metal surface.

2. Immediately after flame conditioning, it is necessary to wire brush the surface before applying any protective coating. Wire brushing will remove partially loose or upturned scale. A clean brush must be used for this work. To obtain the full benefit of this method, the primer or protective coating must be applied to the metal surface while it is still warm, therefore proper timing is essential.

3. Where flame conditioning is used for the removal of moisture only on descaled steel, wire brushing may not be necessary.

4. Extreme care must be exercised on sections lighter than 3/16-inch to prevent any possible warpage from local overheating. Steel plates and shapes can be flame cleaned without causing undue warpage if the metal thickness is greater than 3/16 inch. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed prior to flame conditioning by one of the methods included in this report for that purpose. (See Surface Cleaning)

5. The flame conditioning process is suitable for conditioning of surfaces that have suffered from hydrogen embrittlement. The general procedure requires the removal from the surface of all corrosion, scale and other detrimental products by one of several surface preparation methods. However, blast cleaning is preferred. The clean surface of an embrittled steel may look dark. The passage of a flame or other consequent heating of the metal will cause the hydrogen to escape from the metal. The metal must be heated throughout to a suitably high temperature (200-300 degrees F) to release the hydrogen. It is suggested that this flame treatment operation be followed by a second surface cleaning, again preferably by blast cleaning. Unless the metal has suffered severely, it can be restored to proper usefulness with this combination process. It has also been found advantageous to wash an embrittled surface with warm water thus causing escape of the hydrogen. Here, the metal must be heated throughout to approximately 200 degrees F. However, this method is effective only on surfaces that are not severely attacked.

Safety Measures—Caution. Flame cleaning should not be used if a heavy deposit of iron sulfide is present unless this deposit is first removed by blasting or other suitable surface preparation methods since the sulfur present constitutes a fire hazard.

For use of flame cleaning for the removal of coatings, see Section D, under "Maintenance and Repair Jobs."

Operators must wear safety goggles. Proper precautions must be taken if explosion hazards are present. In enclosed areas, proper ventilation must be provided.

F. Nozzle Blast Cleaning

1. Open Dry System

1.1. This system employs near uniform grain size abrasive particles which are discharged through a nozzle outlet of specific size at a predetermined pressure, thus creating an abrasive particle velocity which produces sufficient impact and abrasion to remove mill scale, corrosion and other undesirable products from steel, before protective coatings are applied.

1.2. The commercial cleaning rate of air blast on steel sheets and plates using a 3/8 inch diameter nozzle and 90-lb. air pressure will average from 3 to 6 sq. ft. per minute, depending on the degree of cleanliness required, abrasive particle size and type and nature and thickness of scale on the steel. This nozzle would deliver approximately 72 lb. of abrasive (metallic) per minute and require about 36 HP. An average cleaning figure would be about .125 sq. ft. per minute per horsepower.

1.3. Oil and grease and other contaminants detrimental to the performance of coatings to be applied must be removed prior to blasting, by one of the methods included in this report for that purpose. Brushes are to be kept clean from these contaminants, otherwise spreading of contaminants will induce early coating failure. (See Surface Cleaning)

1.4. In order to reduce the health hazard caused by a high percentage breakdown of the blast abrasive, the selection of a very clean and hard abrasive becomes extremely important. The scale, rust and other products removed from steel will produce an uncontrollable quantity of dust and waste. If it is at all possible, good blast abrasive should be reclaimed and reused until a maximum abrasive particle breakdown makes its further reclaiming uneconomical. Avoid contamination of reclaimed abrasives.

Safety Measures—All blasting equipment must be grounded to prevent shock from static electricity.

2. Cabinet Blasting

2.1. The aforesaid description of equipment and results as outlined under the Open Dry System is also applicable to a ventilated cabinet blasting system.

2.2. In fully enclosed cabinets, the operator handles the blast nozzle from the outside through a shielded opening in the cabinet. Safety helmets and air supply to the operator can be omitted in this operation. Safety goggles and gloves should be worn. The cabinet and blasting equipment should be properly grounded. The use of a light reflecting paint on the inside will help vision during operation.

3. Closed Recirculating System

3.1. In addition to the conventional open systems, there are also available closed portable systems which employ the continuous recirculating method.

3.2. The continuous system uses synthetic abrasives or steel grit and shot. While sand can be used with this system, its breakdown rate will require a too frequent recharging.

3.3. The abrasive is discharged from the blast nozzle in the same manner as outlined in Paragraph 1 on the Open Dry System of blasting. However, the nozzle is enclosed, permitting recovery of the grit immediately upon impingement of the surface. A brush is mounted to the enclosure and acts as the surface sealer. The abrasive is returned to the blast tank through a large hose, is cleaned and recirculated until it disintegrates. Separate suction is required for the recirculation process.

3.4. For angles, frames pipes and other shapes, brush shapes and cup enclosures must conform to the shape of the work. The adoption of this type of equipment should be carefully studied as its limitations permit use only under certain conditions.

Safety Measures—All blasting equipment must be grounded to prevent shock from static electricity.

In this closed system, the operator handles the blast nozzle as a shielded unit. Safety helmets and air supply to the operator can be omitted in this operation. Safety goggles and gloves must be worn.

4. Open Wet System

4.1. The open wet system is comparable to the Open Dry System, except for the addition of water. (See Open Dry System, F.1.)

4.2. In order to reduce dust to a minimum, the wet blast system employs a mixing chamber at the blast tank or near the blast nozzle, where water, or a mixture of water and an inhibitor, is added to the sand or synthetic abrasive before it leaves the nozzle. In this manner, the moisture subdues most of the dust and in some cases the operating conditions are more favorable and healthful.

4.3. Care must be exercised in selecting the wet system, since a sludge deposit generally remains on the surface after the blast job has been completed with this system. Either a clear water rinse, air blast blow-off, or light brushing with horsehair brush, should be employed in order to properly remove the residue from the surface. A surface thus treated with an inhibitor should not be cleaned with a wire brush, since bristle scratches will destroy the protective film resulting from the inhibitive treatment.

4.4. Average production with the wet system is about the same as with a dry system for blasting. However, the user must bear in mind that additional set-up and clean-up time is required, which ranges from 10 percent to 50 percent more than for dry blasting. Exception is made in some close tolerance (micro-finish) work where fine abrasives are used, as is shown under 5.

4.5. A suggested solution to use in a wet system to inhibit corrosion is as follows:

- 4/5 of 1 quart diammonium phosphate
- 1/5 of 5 quart sodium nitrite (do not use nitrate)
- 15 gallons of water
- Agitate and dissolve all chemicals properly.
- A clean water rinse must follow this treatment.

Note: The W.P. 1 vinyl pretreatment (see J-6), or modifications thereof, has been used satisfactorily on a surface inhibited with this formula, providing all of the blast dust and inhibitor salts have been removed before application of the vinyl pretreatment.

As an alternate to the above diammonium phosphate-sodium nitrite solution, one can use water containing any of the following inhibitors:

Water containing 0.2 percent by weight of:

- 1) Chromic acid, or
- 2) Sodium dichromate, or
- 3) Sodium chromate, or
- 4. Potassium dichromate.

On some jobs, where inhibitors are not used during blasting, inhibitors can be fed into the water stream that is used for rinsing. For best results, the prime coat must be applied immediately after the surface has dried, providing the blast dust and detrimental inhibitor salts have been removed.

Safety Measures—To avoid skin attacks and allergies, proper safety equipment and clothing must be provided for operators of wet blasting equipment.

5. Closed Wet System

5.1. This system employs a liquid-abrasive mix, which uses liquids (generally water) or liquid and air as the carrying agent for the abrasive. The mix is recirculated in this equipment. Generally, inhibitors are used in the solution to retard or prevent corroding of the clean sur-

face. In one blast cabinet, the work is fed into one side of the blast chamber, where it is blasted inside of the cabinet and then discharged out of the other side. In a second system, the work is handled by the operator from the outside of the cabinet under protected conditions. It is found advisable to rinse the product with clean warm liquids (generally water) before applying coatings. Considerable use is made of this method by the tool and die industry, also where an extremely close tolerance finish must be produced for coating work.

Safety Measures—To avoid skin attacks and allergies, proper safety equipment and clothing must be provided for operators of wet blasting equipment.

6. Surface Conditions after Blasting

In order to establish surface tolerances for a specific end result, three surface condition classifications for blasting are outlined as follows, after having been established under uniform and favorable test conditions, using new flat hot rolled steel plate from warehouse stock.

6.1. These three specific surface conditions are intended to establish a production ratio between the best and the worst surface conditions that can be obtained by blasting under ideal test conditions. They should not be interpreted for the purpose of setting up production rates in field work where the variations in structural shapes and existing conditions reduce these footages considerably. The cost ratio in blasting runs: white—6; commercial—2½; brushoff blasting—1.

6.2. Condition No. 1 is the White Steel Surface Finish, which covers the removal of all visible amounts of paint, corrosion products, mill scale, the grey mill scale binder and other detrimental products, thus exposing the base metal. Under favorable conditions, on new flat hot-rolled steel, single nozzle blasting can produce from 75 to 140 sq. ft. per nozzle hour (5/16 inch nozzle at 100-lb. nozzle pressure). It is suggested that nozzle distance from steel surface be 6 inches to 12 inches).

6.3. Condition No. 2 is the Commercial Surface Finish, which includes the removal of all paint, corrosion products and tight and loose mill scale. It does not include the removal of the grey mill scale binder. Traces of tightly adhered surface stains of rust may be tolerated. A commercial blasting job will look rather streaky. Under favorable conditions on new flat hot-rolled steel, single nozzle blasting can produce from 240 to 450 sq. ft. per nozzle hour (5/16 inch nozzle at 100 lb. nozzle pressure). It is suggested that nozzle distance from the steel be 10 inches to 18 inches).

6.4. Condition No. 3 is the Brush-off Surface Finish, which includes the removal of corrosion products as well as of the loose mill scale. It does not include the removal of the tight mill scale or surface stains of corrosion products. However, the abrasive does produce on the tight mill scale an anchor pattern which is found fully suitable for either an adhesive or bonding type coating. Under favorable conditions, on large areas of new flat steel, single nozzle blasting can produce 650 to 1000 sq. ft. per nozzle hour (5/16 inch nozzle at 100 lb. pressure). It is suggested that nozzle distance from the steel surface be 12 inches to 20 inches.

6.5. Before blasting a steel surface, any excessive amount of contamination should be removed by one of the methods outlined in this report. (See Surface Cleaning)

6.6. The aforesaid surface conditions can be held within understandable tolerances. They do prove economical and practical. The approximate average abrasive discharge runs 8 to 30 lb. per minute of blasting time with 5/16 inch nozzle, operating under 100 lb. pressure, using a 30 to 50 mesh abrasive. In estimating sand or similar abrasive use and speed of surface preparation, judgment must be used where structural and complicated shapes or maintenance work are to be treated.

6.7. The relative advantages of these three specific conditions can be determined by comparing surface preparation costs and surface and service conditions. The choice among the three conditions depends on the relative severity of the environments to which the surfaces will be

exposed. The surface subject to impact, immersion, or chemical environments, should be prepared by commercial or preferably white metal blasting.

6.8. In a marine environment, from the deck line to bottom, the surface should be prepared by a commercial or preferably a white metal blasting. On super-structures and other atmospheric environments, brush-off and preferably commercial blasting should be used. In some chemical environments, nothing less than white surface blasting should be accepted.

6.9. Caution must be exercised when blasting thin metal due to possible warpage and deformation that may result. Proper selection of blast abrasives and pressure setting is important when thin sheets are blasted. Lower impact velocity resulting from smaller or lighter abrasives and/or reduced air pressure, can reduce or prevent warpage or deformation of the metal. In general, the cleaning rate may be sacrificed when these changes are made.

Note: For pictorial illustrations of the above three end conditions, see ASTM "Pictorial Standards on Classifying Ferrous Surfaces for Painting."

7. General Notes on Blasting

7.1. Definition of Surface Anchors and Measurement.

A surface anchor which is the height of anchor profile is defined to constitute the height of the metal that extends from the bottom of the anchor pit to the top of the anchor peak. Measurement of the anchor can be made by carefully grinding a flat spot on the blast cleaned surface with a fine grinding wheel ($\frac{1}{2}$ -inch to $\frac{3}{4}$ -inch in width). When the anchor points or valleys are about removed and a smooth surface appears, the distance between the top of the anchor peak and the ground flat spot can be measured with a depth micrometer (pointed shaft instrument) which reads to the one ten thousandth of an inch.

Commercial blast abrasives used in commercial blast equipment can produce the following approximate anchors, depending on abrasive particle velocity, particle size and shape of particle, or nozzle distance, and hardness of metal or particle:

- Synthetic or sand from 80-12 mesh, anchor depth from 1 to 6 mils.
- Metal Grit G-60 to G-16, anchor depth from 2 to 11 mils.
- Metal Shot No. S-230 to S-390, anchor depth from 2 to 8 mils.

These measurements were made on average structural plates. There will be a sight variation when either thinner or heavier plates are used in operation. These figures are to be used as a guide only. Some metallic shot abrasives will fracture, thus making a grit from the shot and cause a proportional increase in the anchor depth.

7.2. The ultimate protection offered by a paint system is dependent on the amount of paint which covers the peak of a surface anchor. The use of abrasives and blasting techniques which produces a coarse anchor pattern should be avoided. Some tests indicate that for a 6-mil paint film, the anchor pattern should not exceed 2 mils. The selection of 30 to 50 mesh sand discharged from a $\frac{5}{16}$ -inch nozzle at 100 lb. pressure, will provide an anchor pattern of approximately $\frac{1}{2}$ -mil depth.

7.3. Sand or other abrasives that are to be reused must be screened to original sizing in order to reproduce a near uniform anchor depth. Contaminated sand should not be reused. In dry blasting operations, sand should be completely dry before reuse.

7.4. If a sand is used, the particles should be nearly uniform in size and the sand should be free of clay. In some cases where clay was present, examinations have shown, the clay packed into the bottoms of the pits created in blasting and became the source of possible paint failure.

7.5. Steel that has suffered from hydrogen embrittlement through adverse service conditions will discolor to an extent where it cannot be properly blast cleaned for painting. It is recommended that embrittled steel be blast cleaned then followed by a flame treatment. The embrittled metal must be heated throughout to a temperature from 200-350° F. Surface heat will not remove the

hydrogen. The salts and oxides are finally removed with a second quick blasting of the surface. (See Flame Conditioning, Section E.)

7.6. A properly blasted surface is excellent for industrial work. Yet, there are factors which prevent its use in many cases.

- a) Possibilities of fire or explosion from electrostatic sparking eliminate its use in hazardous areas. All blasting equipment must be grounded to prevent shock from static electricity.
- b) Flying sand and dust particles make it inadvisable in some areas having a concentration of machinery due to possible damage to moving parts and bearing surfaces unless properly protected by masking.
- c) Danger of damage to the eyes, as well as the respiratory system, limit its use in areas with many personnel who are not involved with the blasting operation and consequently are inadequately protected, unless proper protection is provided for them.

7.7. More extensive use is being made of blast cleaning of metal prior to the acid pickling operation. The blast abrasive removes the scale, produces a deeper anchor than is possible by pickling alone and it also compacts the metal. The pickling process removes from the metal those minute imperfections and scale trapped in crevices. It also develops a finer anchor pattern than that feasible with blasting alone.

G. Wheel Blasting

1. This system employs a grit or shot which is discharged at a sufficient velocity to produce impact and abrasion adequate to remove mill scale, corrosion and other undesirable products from steel before protective coatings are applied. The abrasives are propelled by the centrifugal action imparted by a paddle wheel.

2. Various types of abrasive are available for use with this type of application. Abrasives are:

- a) Chilled iron-shot and grit
- b) Malleable iron-shot and grit
- c) High carbon steel shot
- d) Cut wire abrasives
- e) Synthetic non-metallic abrasives containing no free silica
- f) Nut shells, corn-cob meal

and various other organic abrasives of vegetable derivation used for specialized applications. Most of these abrasives are available in various grades. Sand, aluminum oxides, etc., may be used in air blast equipment, but are not recommended in centrifugal blast equipment due to excessive wear on mechanical parts.

3. Tests have been reported in which abrasives with long fatigue life gave the lowest operating costs due to low rate of abrasive breakdown and lower wear on machine parts. An efficient abrasive recovery system should be used to make the operation economical.

4. A $2\frac{1}{2}$ inch x $19\frac{1}{2}$ inch diameter wheel for centrifugal blasting requires from 15 to 30 HP on the drive and will clean from 20 to 40 sq. ft. per minute depending on particle size, thickness of scale on metal and degree of cleanliness desired, etc. This wheel will deliver an average of 400 lb. of metallic abrasive per minute at velocities up to 14,000 ft. per minute. This will be an average of 1.5 sq. ft. per minute per horsepower, or more than ten times the area per horsepower as compared with air blasting. Consumption of abrasive

will vary from 3½ lb. to 50 lb., depending on the quality of abrasive and type of work involved.

5. Centrifugal wheels are made which deliver up to 1000 lb. of abrasive per wheel per minute and cleaning lines may consist of an unlimited number of wheels. Abrasive grit and shot can be recirculated from 50 to over 5000 times, depending on the operation.

6. The surface roughness is dependent upon the size and shape, hardness, velocity of the abrasive medium, blast exposure time and the physical properties of the metal being blasted.

7. As a general rule, metal abrasive materials are used on indoor blasting operations. Metal abrasives should be kept dry to maintain uniform abrasive flow rate. In general, air blast equipment is used where the equipment must be moved to the work and wheel blast equipment is used where the work must be moved to the equipment. Size and shape of work are other factors. If the possible abrasive recovery rate is high, metal abrasives are most economical. Where recovery rate is low, sand and other less costly abrasives are preferred.

Safety Measures—Nozzle blast operators in vicinity of blast dust must wear suitable safety equipment, to which fresh air can be supplied.

Those working in the vicinity of a blasting operation if subjected to dust must wear suitable respirator apparatus to filter out the dust. Protection against flying particles must be provided also (goggles, gloves, etc.).

Proper precautions must be taken if blast operation is performed in or near an explosive environment. Blast hoses and equipment must be grounded to prevent static conditions. Remote electric sand flow controls are recommended near blast nozzle to allow operator to cut the sand flow on and off. The present practice of kinking blast hose to shut off blast abrasive flow is not recommended. Blast hose is to be kept as short as is possible to reduce friction losses.

(See Bulletin Published by National Safety Council for Blast Cleaning)

H. Chemical Pickling

1. Pickling in an acid bath removes scale and rust from the steel chemically. Grease, oil and drawing compounds must be removed from the surface prior to the pickling operation (See Surface Cleaning). It is common practice to immerse the steel product in a solution of sulfuric, hydrochloric or phosphoric acid for sufficient time to remove the rust and scale. After pickling the work is thoroughly water rinsed to remove the acid from the surface. Under some conditions, this smut is removed by scrubbing of the surface in this operation or during the alkaline-water-neutralizing rinse.

2. In some cases, the water rinse is followed by a chromate or phosphoric-chromic rinse to retard corrosion development prior to further finishing. Alkali rinses are also sometimes used to retard

surface oxidation after pickling, but this alkali must be neutralized before application of an organic finish.

3. Although wide ranges of acid strength and composition in pickle baths are commercially used, the following are typical for mild steels.

- a) 3% to 10% by weight of hydrochloric acid used at an operating temperature of 75 degrees F to 115 degrees F gives an average treating time from about 40 down to 5 minutes.
- b) 3% to 10% by weight of sulfuric acid used at the maximum practical operating temperature of 150 degrees F to 190 degrees F gives an average treating time of about 20 down to 5 minutes.
- c) For certain limited applications, phosphoric acid may be used. A 10% to 20% phosphoric acid bath operated up to 190 degrees F gives a treating time of about 20 minutes down to 5 minutes. (Sludge formation is high with this treatment.)

4. The use of inhibitors in hydrochloric, sulfuric and phosphoric acid pickling is considered necessary for reducing attack on the base metal and diminishing hydrogen embrittlement while removing the scale and rust.

5. Pickling of steel should reach an end point when all corrosion products, as well as loose and tight mill scale, have been chemically dissolved or removed from the metal. The metal will have a fine textured anchor pattern for a subsequent coating application.

6. Hydrogen embrittlement, smut deposits and the end use for which the product is to be used should be given due consideration before selection is made of a chemical pickling process.

7. Steel surfaces properly chemically pickled and rinsed will provide a satisfactory substrate for finishing. These surfaces when finished will provide better service life than the original surface by removing the deleterious deposits that cause premature coating failures.

8. Pickled steel must be primed as quickly as possible to prevent considerable and harmful rusting.

9. Fumes from sulfuric, nitric, hydrochloric and particularly hydrofluoric acids are corrosive and toxic and must be hooded and vented with corrosion resisting materials. Precautions to safeguard the operators must also be taken. (See Bulletin published by National Safety Council.)

10. Nitric and hydrofluoric acids are used for pickling and cleaning of stainless steel and nitric, sulfuric and hydrochloric mixtures for pickling monel and other high nickel alloys.

Note 1—Steel prepared by any of these three chemical processes must be pretreated or must be primed as quickly as possible to prevent formation of undesirable oxides.

Note 2—More extensive use is being made of the

combination blast cleaning-pickling process in production operations. Here the abrasive removes the scale prior to pickling. It also produces a deeper anchor for the coating, than is possible by pickling only. Blasting compacts the metal. Pickling removes from the metal those minor imperfections and deposits trapped on the surface or in crevices. It also develops a finer rather than a coarser anchor on the blast pattern than is feasible by blasting alone.

1. Electrolytic Pickling

1. The process consists of anodic work and cathodic assembly, or the reverse thereof, submerged in a suitable electrolyte. Current is adjusted to a density as found specifically required for the job.

2. In order to speed up the chemical pickling and cleaning processes herein summarized, the application of suitable electrolytic currents to these processes has come into general use. These applications cover both pickling and cleaning baths in which the work is made either the cathode, the anode, or alternately the anode and cathode at intervals, usually of a few seconds each during the treatment. For certain specialized applications, the use of 25 and 60-cycle alternating current have resulted in improved pickling or cleaning operations. The use of superimposed alternating and direct current has been reported, but the economics are seldom favorable for this more complicated equipment.

3. When the work is made the cathode, in either pickling or cleaning solutions, the chemical reactions are aided by the mechanical prying action under the scale of the liberated hydrogen and by the agitation of the electrolyte at the metal surface. In cathodic pickling, particularly with hot acids, the oxide scale is reduced to a lower oxide or to iron, thereby making the scale more soluble in the acid bath.

4. The chief advantage of cathodic pickling is that chemical etching may be minimized with the resulting loss of very little or no metal from the work. The chief disadvantages of either cathodic pickling or cleaning are that loosely adherent metal deposits are often formed and that hydrogen embrittlement of the steel often occurs in some electrolytes. Also see heat treatment of metal under 7.5.

5. When the work is made the anode in cleaning solutions, the liberated oxygen aids in causing surface agitation of the electrolyte and in causing a mechanical prying action. When the work is made the anode in pickling solutions, the chemical reactions are aided by the anodic etching reactions, which cause a loss of the metal being treated. For high production rates, both anodic pickling with a suitable inhibiting agent and anodic cleaning are coming into more general use.

6. Modern high speed continuous cleaning and pickling mills often use a combination of anodic and cathodic treatments in both the cleaning and pickling baths. Often no electrical connections are made to the work, but it is passed between alter-

nately arranged cathodes and anodes either in the same tank or adjoining tanks. Alternating current is being used for the power supply to the electrodes of some of the modern continuous mills, but direct current is generally favored.

7. For each application, the current density is adjusted to a value found to be specifically suitable. Current densities of 10 to 75 amperes per sq. ft. are generally used for anodic treatments and current densities of 100 to 300 amperes per sq. ft. are common for cathodic treatments or where alternating current is applied.

8. In general, the operating compositions and temperatures of a chemical cleaning or pickling bath will be satisfactory with but slight modification for the corresponding electrolytic treatments. The maximum practical operating temperature is usually desired. In comparison to chemical or cathodic pickling, anodic pickling is considerably more independent of the bath composition. Electrolytic pickling and cleaning in molten salts or molten caustic baths produce clean, corrosion-free surfaces and to a large extent are free from the disadvantages of acid pickling. Metals must be neutralized and rinsed and dried prior to painting.

9. The treating time for electrolytic pickling or cleaning is generally considerably faster than the corresponding chemical pickling or cleaning operation without the electrolytic treatment. In continuous mills, the treating time is often less than ten seconds and for intermittent operations, the time may be set at any desired value to 30 minutes or more.

10. Hoods for removal of dangerous fumes and gases should be provided. Fumes from sulfuric, nitric, hydrochloric and particularly hydrofluoric acids, are corrosive and toxic and must be hooded and vented with corrosion resisting materials. Precautions to safeguard the operators must also be taken.

11. *Electrolytic Pickling, Using Seawater as an Electrolyte.* This method of surface preparation has had limited commercial use. Reports indicate that the following system has been successfully used for the removal of heavy scale formation: (This method of surface preparation has had limited commercial use.)

- a) The inner surfaces of a heavily corroded steel storage tank or a compartment can be derusted by a modified cathodic pickling process. Hard, firmly attached rust layers of any thickness up to more than $\frac{1}{4}$ inch are easily descaled. A brine containing a suitable quantity of the mineral acid salts of magnesium, calcium and sodium is used as an electrolyte. The natural concentration of these salts in seawater approaches an optimum for the process. The availability for all marine uses of such a ready-mixed electrolyte at no cost other than pumping, is an essential feature of the low operating costs.
- b) A typical proprietary treatment consists in arranging suitable anodes in the com-

partment to be treated, filling the compartment with seawater, cathodically treating the surface, pumping out the solution, hosing down the derusted surfaces and mucking out the piles of rust scale. The descaling at the metal-rust interface is accomplished by the combined mechanical prying action of the liberated hydrogen gas and of the solid calcareous coating when densified by the deposit of enough magnesium hydroxide to plug the intercrystalline pores of the calcareous coating. The resulting pressure ruptures the bond between the rust layer and the steel surface. By continuing the operation, a dense protective calcareous coating can be deposited which materially reduces further corrosion of the surface. However, for the application of an organic coating immediately after the descaling operation, the final preparation of the surface can be accomplished either by blasting or by a surface wash containing one or two percent of hydrochloric acid or phosphoric acid, followed by a water rinse.

12. Poultice System of Chemical Surface Preparation. This method of surface preparation has had limited commercial use. The poultice is applied in the form of a blanket which can be saturated with dilute acids or acids and inhibitors. The treatment usually consists of the original acid inclusion which is mixed with the poultice before its application on to the metal. The "blanket" is then saturated with additional dilute acid and/or inhibitor until sufficient action has completely removed mill scale, rust and other deleterious products, thus leaving a clean surface as the result of this chemical action. Upon completion of the reaction, the poultice can be removed with scrapers, followed by a water rinse, or it can be washed off with water directly. The poultice blanket may be 1/16 inch to 1/4 inch thick and can be made from any product of suitable cohesion to form the blanket. It must be sufficiently inert to the acid that the reaction will be on the metal and not with the material of the poultice.

J. Surface Conditioners

1. Surface Cleaning

Scope: The surface cleaning process with solvents, alkalis, and emulsions, is for the purpose of removing all contaminants, great, oil, etc. Surface cleaners do not react with the metal. The metal thus treated must be painted immediately, or followed by either the *surface reaction* or *surface conversion* treatments, as described in Section J.2 and 3.

1.1. Cleaning with Solvents

a) Organic solvents are used in various ways to remove soil from metal surfaces. In small shops, or on large structural projects, where mechanical cleaning equipment is not available or cannot be economically employed, the practice is to wipe the surface of the metal with rags wetted with solvents. This cleaning method leaves much to be desired. The rags and the solvents quickly become contaminated with oil and grease and a light film of oil and grease is usually left on the metal surface. Rags must

be kept clean during hand wiping and dirty solvents must be discarded. Salts, alkalis, acids, chalk marks, some drawing compounds and other foreign elements are insoluble in organic solvents and cannot be removed by such expedients. When this method of hand cleaning is necessary, primer with a high tolerance for oil should be used as the base coat for the finish.

b) The most satisfactory method of solvent cleaning is the vapor degreasing process. In this process, the metal is passed through hot solvent vapors that condense on the cooler metal and wash the surface. The principle of the vapor degreaser is quite elementary. Equipment for the process consists of a solvent tank or boiler provided with a thermostatically controlled source of heat. Above the boiler is a vapor chamber. The top walls of the vapor chamber are cooled to a predetermined height to provide a condensing area that does not permit the hot vapors to escape from the top of the chamber. Then the system is in operation, the solvent is held at boiling temperature and the metal to be cleaned is constantly washed by clean solvent condensing from the vapor phase. In many vapor degreaser systems, it is common practice either to immerse the work in the solvent, or to spray solvent on the work before passing through the vapor chamber. This step will remove the major part of the oil and grease and greatly reduce the time necessary in the vapor chamber. When properly done, vapor degreasing will completely eliminate oil and grease from metal surfaces, also from seams and intricately formed parts of fabricated articles. Fire hazards usually present in other solvent cleaning processes are not a threat because the chlorinated organic solvents used in degreasers do not ignite at ordinary temperatures.

c) Increase in the boiling point of the solvent points to oil contamination and distillation or disposal of the solvent is required to remove the fire hazard. Solvent reclamation by distillation is an important phase of this cleaning operation and adds to the lowering of operating costs. Special distillation equipment can be supplied by manufacturers of solvent cleaning equipment.

d) Vapor degreasing has its disadvantages, in that it will not remove mill and shop soil without spraying or wiping. Also, vapor degreasing will not remove soap or water soluble salts. A water rinse, preferably inhibited, after the vapor degreasing operation is beneficial in removing these materials.

e) Solvent cleaning is probably the best method for removing waxes from metal surfaces.

f) Primers must be applied to solvent cleaned surfaces as quickly as possible to prevent the formation of rust.

g) Most vapor degreasing solvents create a health hazard that should be considered in the installation of this type of process. For information, consult National Safety Council and local authorities.

h) There is another important hazard in the use of chlorinated solvents. These materials tend to decompose and form hydrochloric acid, which if left on the metal surface, causes excessive corrosion. Generally, commercial cleaning solvents contain stabilizers to minimize this defect. However, for continued use of these solvents, additional stabilizer make-up may be required.

1.2. Cleaning with Alkaline Compounds

a) Cleaning of metal surfaces by alkaline solutions is another widely used method. Usually these solutions are a mixture of two or more compounds, some of which are soluble alkaline silicates, phosphates, carbonates and hydroxides. Rosin, soaps and other emulsifying agents are sometimes added to the alkaline mixtures.

b) Other additions to alkaline cleaners are the so-called wetting agents, such as the sodium salts of sulfonated alcohols. These compounds lower the surface tension between the metal surface and the solution and accelerate the cleaning process because of the better wetting qualities of the solution.

c) The formulation of alkaline cleaners covers a wide range and suitable cleaners are available for almost every type of metal cleaning, from heavy grease to light oils. They will remove shop dirt, soil, hand marks and acid, except insoluble compounds, such as chalk marks and corrosion products.

d) Two methods are employed in alkaline cleaning—"soak" or immersion cleaning and mechanical washing with sprays. The immersion process consists of dipping the metal parts in steel tank, provided with a source of heat. Heat is an important factor in alkaline cleaning and an adequate supply must be available when speed and

thorough cleaning are necessary. A solution that will do a thorough cleaning job at 212 degrees F in two minutes may require 7 or 8 minutes at 200 degrees F, or 12 to 15 minutes at 165 degrees F.

e) There are available also electrolytic alkaline cleaning processes, using both the anodic and cathodic methods as outlined in Section I, resulting in a speedier cleaning of the parts involved.

f) Solutions used for immersion cleaning carry much higher percentages of cleaner than those used in mechanical or spray units. For example, 2 to 6 oz. per gallon of cleaner are used in a soak tank, while $\frac{1}{4}$ -oz. to 1 oz. per gallon is enough for the mechanical washer. The difference in the cleaner content of these two solutions indicates the great advantage of the washing action of the solution when applied to the metal surface by sprays under pressure. Because of the greater efficiency of the mechanical unit, it is widely used in volume production.

g) Metal cleaned in alkaline cleaning solutions must afterwards be thoroughly rinsed in clean water. A rinsing procedure that fails to remove all residual alkali will give unsatisfactory results, since most organic finishes are adversely affected by alkalies. Traces of alkali on the metal surface in most cases are even more detrimental to organic finishes than traces of oil or grease.

h) The most satisfactory alkaline cleaning system includes an acid or neutralizing rinse following the water rinse. Four to six oz. of chromic or chromic-phosphoric acid per 100 gals. of water may be used for this purpose and is permitted to dry on the metal. These materials neutralize traces of alkali and appear to partly passivate the metal surface. Greatest effect is accomplished under elevated temperatures. When properly used, these rinses will prolong the life of the finish considerably. To reduce shop dirt and other contaminations to a minimum, a prime coat should be applied as quickly as possible after drying.

i) Due to the attacking nature of most alkalies, the workmen in these operations must be protected from contact with the alkaline materials and the vapors therefrom. Particular attention should be paid to the eyes and skin.

j) The end pH at the metal interface should be between 5 and 7 pH and can be established by the use of pH test paper.

1.3. Cleaning with Emulsions

a) Emulsion cleaning is also employed to some extent. Organic solvents, such as kerosene, are emulsified with pine oil, soaps, or other emulsifying agents and applied to the metal by immersion or spray. Additions of small amounts of alkali compounds to these emulsions are sometimes recommended where heavy greases or oils are to be removed.

b) Emulsion cleaners are especially advantageous as mediums for removing oil, grease and other soil from steel ahead of chemical treatments that convert the surface; i.e., phosphate coatings. They may help to retard rusting between stages of spray units and are beneficial where storage of cleaned metal between operations is a factor. Some emulsion cleaners are beneficial to a limited degree in retarding corrosion.

c) Emulsion cleaners, by themselves, are often used as a surface cleaning treatment prior to painting. However, surfaces so treated must be thoroughly rinsed with clean water prior to application of paint.

d) Where alkalies are used in this operation, proper precautions must be taken, as indicated on Section J.1.2 on Cleaning with Alkaline Compounds.

1.4. Steam and Hot Water Cleaning

a) The equipment supplies steam and/or hot water under pressure to one or more nozzles. The method is used in applications where the soil and other deleterious products can be dissolved and removed with water.

b) In these cases, wetting agents and/or detergents or other cleaning agents are added to the steam, thus increasing its cleaning effectiveness. Where detergents, alkalies, or wetting agents are used this treatment must be followed by a water rinse.

1.5. Water Cleaning Under High Pressure

a) The equipment employs water under high pressure (200 to 650 psi). In some cases, high pressure air is used to eject water against a part or surface, thus removing soil and other deleterious products. In some operations, it is found advantageous to use wetting agents or other

detergents with the water. Reclaiming these solutions has been found practical and economical. Where detergents, alkalies, or wetting agents are used this treatment must be followed by water rinse. Precautions must be taken to safeguard operators and personnel against the forces in this system.

2. Surface Reaction

Scope: Surface reaction with dilute acids produces a slight etch on the metal. Since the reaction is only slight, paint should be applied after the metal so treated has dried and before deleterious products can deposit or form.

2.1. Reaction by Acid Cleaning

a) Alcoholic phosphoric acid cleaners consist of phosphoric acid and an organic grease solvent. Some of these cleaners contain wetting agents. They are reduced with water to produce a solution for cleaning steel.

b) They may be used to remove light deposits of grease, oil, rust and light annealing oxide. Heavy drawing compounds should be removed from metal by a surface cleaning method prior to the use of acid cleaners (See Surface Cleaning). They are not recommended on surfaces having heavy rust or mill scale present.

c) There are two types, wash-off and wipe-off and they are generally applied at room temperature by brush, swab or steel wool.

d) After treatment, articles cleaned with the wash-off type should be rinsed with clean water, preferably hot, to facilitate drying. The wipe-off type should be wiped with clean rags (first wet and then dry). Residue of unreacted acid should be removed for best finish results by rinsing with clean water or thorough wiping.

e) Metal cleaned with acid cleaners should be thoroughly dried before painting.

f) Metal surfaces properly cleaned with acid cleaners provide a satisfactory base for most finishes as a result of the etch obtained. Finished metal surfaces cleaned with a reaction process are superior to the metal surfaces cleaned by cleaning methods noted previously, which do not etch the metal (see Surface Cleaning). To minimize redeposit of shop dirt and other contaminants, a prime coat should be applied as soon as is possible.

g) Normal precautions for handling of acids must be followed. (See National Safety Council and Manufacturing Chemists Association bulletins)

2.2. Spray Chemical Cleaning and Pretreatment

a) Dilute alkali phosphate solutions with detergents are designed to simultaneously clean and condition rust-free iron and steel surfaces in preparation for paint. These solutions deposit an iron phosphate coating.

b) The solution is operated at temperatures of 150 degrees F to 170 degrees F and is sprayed in a power washer. It has particular merit where three- or four-stage washers are available.

c) The process for application is generally as follows:

System 1—Stage 1—Spray chemical cleaner and pretreatment

Stage 2—Spray water rinse

Stage 3—Spray acidified rinse

System 2—Stage 1—Spray chemical cleaner and pretreatment

Stage 2—Spray chemical cleaner and pretreatment

Stage 3—Spray water rinse

Stage 4—Spray acidified rinse

d) The treatment produces a surface on base metal over which most organic finishes will have better durability and adhesion than they do over alkali, acid, or solvent cleaned surfaces. It also inhibits rusting of iron and steel parts between operations.

e) To minimize redeposit of shop dirt and other contaminants, a prime coat should be applied as soon as is possible.

f) Proper safety precautions must be applied when using these treatments. (See information published by National Safety Council and Manufacturing Chemists Association)

3. Surface Conversion

Scope: Surface conversion generally involves the forming

of a compound of the metal on its surface which is less corrodible than the metal itself.

a) Surface conversion is brought about by chemical solutions which produce a non-metallic deposit on the surface adapted to inhibiting corrosion and increasing the adhesion and resultant durability of most organic finishes. Generally, the deposit is a metal phosphate, chromate or oxide and others.

b) The increase in durable life of the organic finish is due to:

- 1) Insuring a chemically clean, grease-free surface for organic finishes.
- 2) Providing a corrosion-resistant surface. A high electrical resistance of the surface is often associated with this.

c) The process for the application of the surface conversion treatments is generally as follows:

- 1) Cleaning
- 2) Hot water rinsing
- 3) Chemical treatment
- 4) Water rinsing
- 5) Acidified rinsing

d) These surface conversion treatments are accomplished by either immersion application or by power spray washing type equipment.

e) In general, the solution used in this chemical process is heated. The temperatures vary according to the type of solution, from 70 degrees F to 210 degrees F, with some requiring temperatures up to 350 degrees F.

4. Typical Commercial Cleaning, Pickling and Passivating Process for Steel

a) *General Cleaning Prior to Pickling.* Remove from the metal any visible grease or oil deposits by hand or tank cleaning with one of the several processes indicated in this report for that purpose. (See Surface Cleaning, J. 1)

b) Pickling operations are for the purpose of complete removal of all mill scale, corrosion products, surface slivers and other metallic deposits, to leave a plain steel surface exposed, relatively free from all metallurgical contaminants. The steel (or product) shall be immersed in a 5 percent concentration of sulfuric acid, to which is added a specific percentage of a suitable inhibitor. (Proprietary products containing wetting and anti-foaming agents are generally used.) One formulation calls for the addition of inhibitor to be 4/1000 of 1 percent of the amount of the acid in the bath. The inhibitor prevents excessive acid attack on the metal. Where rubber lined tanks are used, the temperature should be held under 150 degrees F, to prevent damage to the rubber.

c) The time of descaling is approximately 20 minutes, depending upon the condition of the surface. Further additions of sulfuric acid are required when the pickling time increases appreciably.

d) The bath shall be discarded when the accumulation of sludge or dispersed sediment of iron and concentration of iron in solution inter-

feres with pickling and causes the steel to come out dirty. This condition of the bath will correspond to a specific gravity of about 1.15 to 1.25.

e) After being lifted out of the sulfuric acid bath, the descaled steel shall be allowed to drain into the acid bath for 20 to 30 seconds before immersion in the water bath.

f) *Water Rinse.* The purpose of the water rinse is to remove all residual sulfuric acid from the steel. This should be an overflowing rinse so that it does not become contaminated with residual acid. The steel should be rinsed for approximately one minute. Satisfactory rinsing can be obtained in either cold or hot water. When smut is present on the steel surface after sulfuric acid pickling, a pressure spray rinse is advantageous.

g) *Passivating.* Pickled steel will rust rapidly and it is advantageous to prevent this oxidation and to provide a suitable surface for finishing by passivating or treating further to obtain a surface conversion coating. Examples are as follows:

System 1—Immerse in a 4 to 6 oz. per 100 gal. of water solution of chromic or chromic-phosphoric acid for approximately 30 seconds. This solution may be heated to facilitate drying of the metal.

System 2—Treat with a chemical solution to convert the surface to a non-metallic deposit as described in J-3. It is sometimes necessary to neutralize the pickled surface with an alkaline solution to obtain the best coating. Instructions from the supplier should be followed.

h) The foregoing approximate composition of the dilute phosphoric acid shall be maintained during the run by occasional additions of phosphoric acid. If the iron content becomes too high at any time, a proportion of the bath must be discarded. The dilute phosphoric acid bath may be used for a number of runs provided the foregoing concentration is maintained and also that the pickled steel when taken from the bath is clean and free from deposits. The time of immersion is about three minutes.

i) The surface must be air or force dried before applying a prime coat.

Safety Measures—In chemical treatments, hooding of permanent operations and proper ventilation are prerequisites.

Rubber clothes, gloves, and headgear should be worn by those working in the immediate vicinity of the processes.

Inflammable materials must be handled and used under precautions recommended by the National Safety Council and as outlined at the meeting of the American Conference of Government Industrial Hygienists in Atlantic City in April 1951, as recorded in the *Archives of Industrial Hygiene & Occupational Medicine*, Vol. 4, Page 398 (1951). Information regarding the handling and storing of dangerous chemicals can be secured from the Association of Manufacturing Chemists.

5. Induction Removal of Mill Scale from Steel

a) The pieces are passed through the induction heating unit for descaling after heat treatment but

preliminary to machining or painting. A frequency of 10,000 cycles per second was used for the experimental work and was adopted for production work also. Power input must be high to obtain the required heating in a very short space of time; an input of 65 kw is used for small bars, and 75 kw on the large pieces.

b) The work passes through the heating unit at the rate of approximately 900 ft. per hour and the surface is heated about 350 degrees F, immediately followed by a water spray. Under these conditions, the scale pops off the surface of the bar cleanly and at the same time the work is not heated enough to cause any additional oxidation.

c) Power cost for cleaning approximately 900 ft. of 3½-inch diameter stock is estimated at \$1.00. Lower power cost, plus reduced handling costs, can make induction descaling an economical means of cleaning.

d) In addition to the descaling of bar stock before machining, the process has possibilities for the continuous descaling of strip, bars, rods, tubes and other simple forms at the mill. One of its greatest advantages is that it can be built into the production line, eliminating scale at a high rate of speed and without an acid disposal problem.

6. Vinyl Metal Conditioner (Formerly Referred to as Wash Primer)

Scope: Metal conditioner is a synthetic resin-chromate-phosphate complex that provides chemical surface conditioning and temporary primer protection to the metal until the protective primer or coating is applied.

a) The vinyl metal conditioner is designed to:

- 1) Give temporary protection against corrosion.
- 2) Retard creepage of corrosion under the paint film where damage has occurred to a paint film.
- 3) Provide a desirable adhesive base for most paint films.

b) The product contains inhibitor, pigment, and binder. It should not be considered as a replacement for the anti-corrosive primer, but as a supplement to the anti-corrosive primer and other paints. The conditioner is considered part of a surface preparation and not of the coating system.

c) Most conditioners set to an insoluble film after being applied to the metal. This property is not appreciably affected by a wide range of variations in either atmospheric temperature or atmospheric humidity. The conditioners will give temporary protection against corrosion, but their use as shop coats is governed by the length of time that they are to be exposed to the weather and the environment as a whole, before the prime coat is applied. While the existing vinyl pretreatments produce a film of .3 to .5 mils, there are a number of new formulations available which can be considered for use as shop coats.

d) These conditioners should be applied to the metal as soon as possible after the metal has been

prepared and before any deleterious attack on the metal has occurred.

e) Some aqueous phosphoric acid, phosphate and other conversion and reaction pretreatments cannot be used before applying the conditioner, due to the lesser reactivity of a partially treated surface. Best results have been obtained when the conditioner comes directly in contact with clean, dry metal. Mechanical or chemical roughening of the steel surface is not a prerequisite to its use, but clean metal contributes to its success.

f) Best service results from vinyl conditioners are obtained if the film applied when dry remains continuous and as heavy non-porous as is practical.

g) There are several different types of conditioners available. All are good for ferrous metals. Variations in these formulations must be borne in mind, depending on the environment and end use of the product.

One of the common formulations is known as U. S. Government Specification MIL-P-15328 (also known as WP-1), is shown here.

	Pounds per 100 Gallons of Mixed Material	Gallons per 100 Gallons of Mixed Material
Ingredients of Resin Component (80 gallons)		
Polyvinyl-Butyral Resin ¹	56	6.10
Zinc Chromate ("insoluble type") ²	54	1.90
Magnesium-Silicate (Type A or B, of Spec. MIL-M-15173).....	8	0.35
Lampblack (Spec. TTOL-70).....	0.6	0.04
Butyl Alcohol, normal (Spec. TT-B-846).....	125	18.40
Ethyl Alcohol (Grade III of Spec. O-A-396 ³).....	380	55.70
Ingredients of Acid Component (20 gallons)		
Phosphoric acid (Class A of Spec. O-P-313).....	28	2.0
Water (maximum).....	25	3.0
Ethyl Alcohol (Grade III of Spec. O-A-396 ³).....	102	15.0

¹ The resin shall be a polyvinyl partial butyral resin containing only polyvinyl butyral, polyvinyl alcohol and polyvinyl acetate in the molecule. The resin shall contain 18 to 20 percent vinyl alcohol and not more than 1.0 percent of vinyl acetate. A 6 percent solution of the resin in methanol shall have a viscosity of 13 to 18 centipoises at 20° C. The specific gravity of the resin shall be 1.05 to 1.15.

² The zinc chromate shall be an "insoluble type", showing on analysis 16 to 19 percent CrO₃ and 67 to 72 percent ZnO, and not more than 1 percent water soluble salts.

³ Isopropyl alcohol (99 percent) may be substituted for ethyl alcohol on an equal volume basis. The isopropyl alcohol shall have a specific gravity of 0.785 to 0.790 and a distillation range not greater than 1.5° C., and this range shall include 82.3° C.

There are available a number of stable pretreatments where acid is mixed with the resin and thinner at the point of formulation. Some of these stable pretreatments are more sensitive to humidities above 70 percent.

h) In many cases, U. S. Govt. Spec. MIL-P-15328 and similar materials, have performed well when applied over slightly moist or damp surfaces. However, paint applications onto this pretreatment must be made when surface is dry.

i) Film thickness gages are available for measurement of these thin film deposits, such as the General Electric Type B; the Elcometer, and the Krouse Gage. Wet film thickness gages are also available for thickness comparison from Interchemical Corp. and Gardner Laboratories.

j) The supplier of these pretreatments should be consulted regarding safety precautions.

7. Oil Pretreatments

a) Pretreating of metal surfaces with wetting oils is a method which intends to penetrate the

fine corrosion products, some types of mill scale and minor dust deposits that may be found on the surface. The pretreatment can be a raw linseed oil, maleic anhydride treated linseed oil, fish oil formulation, or it may be a formulation of these, to which are added other wetting oils, containing thinners and/or driers in some cases.

b) A surface treated with the wetting oil preferably can be painted while the oil is still wet, or in some cases, can be painted after the oil has dried completely.

c) Wetting oils can be applied by either the brush, spray, or dip process. Many commercial paints can be used over or with wetting oils. However, it is suggested that the user check with the paint supplier regarding the oils' compatibility with the coating that must be applied onto a pre-wetted surface.

d) Proprietary oils which have been formulated for suitable wetting are available. The use of wetting oils is generally limited to atmospheric exposures.

K. General Notes on Surface Preparation of Steel

1. For good coating performance, the anchor depth on any steel surface should not exceed one-third of the total thickness of the coating system. As an example, anchor depth for a 6 mil coating system should not exceed 2 mils. It is realized that on pitted surfaces, this uniformity cannot be established. Some correction can be made through the use of heavy film forming coatings.

2. Dust, sand residue and other contaminants must be removed from any surface before a prime or first coat is applied unless a primer can wet and incorporate these residues in the film.

3. Coating life can be prolonged if sharp edges, design variations and demarcations are beveled or rounded for good coating coverage and adhesion.

4. Weld flux slag, weld metal spatter and weld flux fume deposits should be removed completely before a coating is applied. Weld fluxes usually contain a large proportion of alkaline borates which tend to affect the paint film detrimentally. These areas should be mechanically cleaned and neutralized through the use of phosphoric acid treatments.

5. Grinding a surface with an abrasive wheel can be considered a surface preparation method. It produces a good anchor for all types of coatings. However, the metal losses are generally very high and the process is costly. It should be used only where other processes must be ruled out.

6. Where metallizing is to be used as the base for a paint system, the recommended practices for surface preparation and metallizing for corrosion protection as issued by the American welding Society should be followed.

II. Surface Preparation of Zinc, and Galvanized Steel Surfaces

1. It has been found that galvanized steel provides a poor foundation for paint unless given a

pretreatment either at the mill or in the field. Satisfactory results have been obtained from the following treatments:

- a) Weathering for three months to several years, depending on the severity of the atmosphere.
- b) Treatment with salt or acid base materials (proprietary materials are available).
 - 1) Salts of phosphoric acid with phosphoric acid and accelerating agents.
 - 2) Phosphoric acid with grease solvents
 - 3) Simple phosphoric acid treatment:

Alcohol	30%
Phosphoric Acid up to	15%
Water	55%*

 (* or to make up balance of 100% if lesser percentage acid is used)

Each of these materials may be spray-, flush-, brush-, or dip-applied, allowed to dry. They must be rinsed thoroughly with water before application of paint.

- c) On properly cleaned galvanized steel, the use of U. S. Government Spec. MIL-P-15328 (a vinyl metal conditioner) is a good foundation for subsequent coatings (see Specification herein).
- d) Vinegar or acetic acid is not recommended.

2. Soil or contamination should be removed before treatment or painting by one of the aforesaid cleaning processes. Loose oxidation products must also be removed if metal has weathered extensively. There are available suitable coating formulations for use on the above metals.

3. Proper safety precautions must be borne in mind. (See Bulletin published by the National Safety Council)

III. Maintenance and Repair Jobs

1. On maintenance and repair jobs, the surface preparations can be handled as per any of the aforementioned new-steel product systems, with the following exceptions:

- a) Due to the location and character of some maintenance work, for the removal of old coatings good paint removers are at times more economical to use than either a blast, brush or flame cleaning system. Paraffin, present in some paint removers, must be completely removed with a suitable detergent wash, commonly available. The supplier of the remover should be consulted regarding proper safety precautions.
- b) When patch work is blasted or otherwise cleaned, the operator should see to it that the old or remaining paint is feather-edged sufficiently to permit the new coating to form a near uniform surface assembly, using the original number of coats.
- c) When inhibitor is used on old work, care should be exercised that the active inhibitor and/or the inhibitor salts be completely re-

moved before paint is applied. Vinyl metal conditioners can be used beneficially on repair jobs where the bare metal is exposed.

- d) The flame conditioning system is sometimes used for the removal of old protective coatings. However, old protective coatings and grease may carbonize under the flame and leave a residue on the metal which interferes with good adhesion of subsequent protective coatings. Where it is necessary to employ flame conditioning in the removal of protective coatings, proper safety precautions must be observed, because the operator may be subjected to toxic products due to the decomposition of the protective coating. Care must be exercised when old coatings are removed with flame cleaning apparatus and in all instances, proper ventilation and other safety precautions must be observed.
- e) Heavy old coating systems can be removed economically with straight or centrifugal impact tools, as outlined in I. c.
- f) Emulsion type cleaners have been used successfully in the removal of oil films from previously painted surfaces prior to the ap-

plication of paint. When heavy oil deposits are encountered the emulsion cleaning and water rinsing operation must be repeated until the surface is suitably clean to receive the paint or coating.

IV. Assembly of Dissimilar Metals

1. Galvanic action is not always serious in atmospheric exposure, but should be borne in mind where an active electrolyte is present. Assembly of dissimilar metals should be avoided whenever possible. If it is necessary to couple dissimilar metals, the problem of galvanic corrosion is usually present. To prevent this, an insulator must be provided between the two metals. This can be done with barrier type coatings with high resistance. The trend has been to use products such as tape impregnated with a corrosion inhibitor, or a rubber, plastic, or fiber insulating barrier.

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HOUSTON 2, TEXAS

A Laboratory Method For Screening Oil Well Corrosion Inhibitors*

By J. A. CALDWELL* and M. L. LYTLE*

THE USE of inhibitors in oil wells appears at present to be the most satisfactory method of corrosion control. In an inhibitor research program it will be found that there are a great number of substances which should be tested for their effectiveness. These include commercially available materials and products synthesized in the laboratory from such materials. Because a field test of an inhibitor may require six months or more, it is obvious there is a need for a dependable laboratory procedure for screening the many substances available so that only the most promising ones need be tested in the field.

Measurements of contact potential, hydrogen over-voltage, wetting angle and metal weight loss are some of the usual laboratory methods employed in studying corrosion inhibitors. Of these the weight-loss method appears to be the most generally applicable and reliable method for screening inhibitors, the other methods being useful for studying the mechanism of inhibitor action and in screening substances within certain classes of compounds in specialized studies.

Description of Method

This paper describes a screening method used by Humble Oil & Refining Co. in a search for inhibitors for use principally in sour crude wells. Minor modifications such as a change in the source of oil and brine used and substitution of carbon dioxide for hydrogen sulfide, make the method applicable to research on corrosion in other types of wells.

Accurately weighed mild steel coupons are exposed to corrosive fluids from sour crude wells in a laboratory weight-loss test. A 1-inch x 3-inch x 1/16-inch test coupon and a glass device for holding the coupon are placed in a 29 x 300 mm Pyrex test tube having a side arm. The open end of the tube is sealed, the side arm is connected to the filling apparatus shown in Figure 1 and the tube is evacuated with a good water pump. Natural gas is injected and the process of evacuation and filling with gas is repeated four times. After the final evacuation, 50 cc of brine and 50 cc of oil are added through a manifold so constructed as to preclude the possibility of contamination with atmospheric oxygen. Hydrogen sulfide is added in an amount sufficient to bring the total pressure in the tube to atmospheric. The inhibitor is usually added in water or oil solution by means

Abstract

Because a field test of an inhibitor may require six months or more, it is obvious there is need for a dependable laboratory procedure for screening the many substances available. This paper describes a weight-loss test in which accurately weighed mild steel coupons are exposed to corrosive fluids from wells producing sour crude oil. Three sketches of laboratory apparatus are shown. Correlation between laboratory and field test results has been good.

of a hypodermic needle which is forced through the wall of a short length of rubber tubing connecting the side arm of the test tube and the filling apparatus. In special cases other solvents for the inhibitor are used after the solvents have been shown to be inert as corrosion inhibitors. After the filling of the tube is completed, the side arm is sealed off and the tube is mounted on a wheel which is rotated at a rate of approximately 30 revolutions per minute; in this manner the oil and brine are agitated and the steel coupon is alternately exposed to the effects of liquid and gas, thus simulating well conditions to some extent. At the end of 14 days the coupon is removed, cleaned and weighed and the metal loss calculated in inches per year. Results of exposure of a second coupon under similar circumstances except that no inhibitor is added permit calculation of the reduction in coupon corrosion rate effected by the inhibitor under study. A sketch of the revolving-wheel apparatus is shown in Figure 2.

The device for holding the coupon in the test tube is a 7 mm glass rod about seven inches long bent

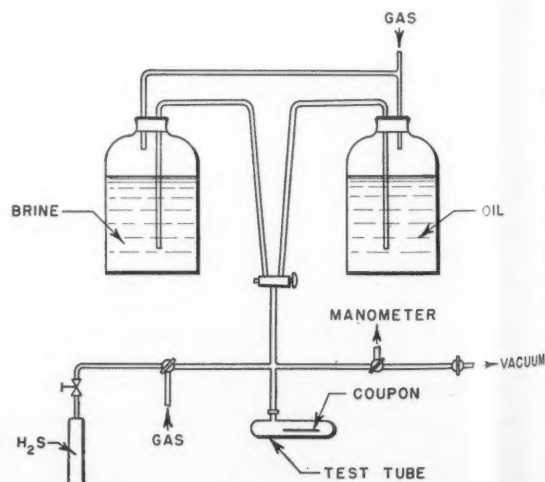


Figure 1—Apparatus for filling test tubes in revolving wheel test.

* Submitted for publication June 2, 1952.

* Humble Oil & Refining Co., Production Research Division, Houston, Texas.

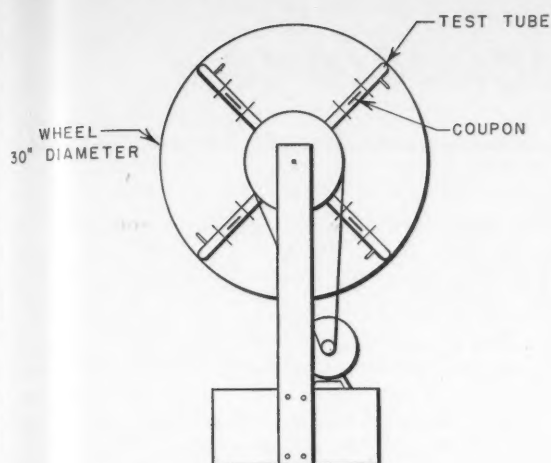


Figure 2—Revolving wheel apparatus.

at an angle of 135 degrees at a point one inch from one end of the rod, passing through a hole in the coupon and bearing against the side of the test tube. The complete assembly is shown in Figure 3. Alternatively, a small but powerful permanent magnet may be taped to the outside of the test tube to hold the coupon in place. The use of the glass rod is preferred because it does not introduce quite as much localized corrosion on the edges of the coupon where contact is made with the glass surface. It will be noted that either device makes unnecessary the exposure of rubber or plastic materials to well fluids. The solvent action of the oil may lead to spurious results when such materials are used to seal the test tube or to hold the coupon.

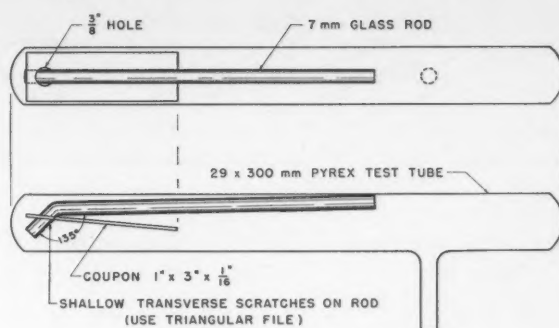


Figure 3—Coupon and holder in test tube.

Correlation With Field Tests

Field tests have been made of some of the materials which gave promising results in the laboratory. Each of several organic materials was tested under closely controlled conditions in one or more of five fields, in four of which sour crude oil is produced. Substantial reductions in rod and tubing corrosion using economically practicable concentrations of inhibitor were effected in each case.

The correlation between laboratory and field test results was further strengthened by results obtained on a test of a different type of organic compound from those mentioned in the preceding paragraph. This compound gave good results in the laboratory test with well fluids from a particular field producing sour crude and gave good results in the field trial. The same compound which gave erratic results in the laboratory test with fluids from a different field producing sour crude, after a six months' test in the second field apparently did not reduce corrosion failures of well equipment.



Discussions

Kel-F Applications in Corrosive Systems by L. C. Rubin and W. O. Teeters. *Corrosion*, Vol. 9, No. 3, 100-102 (1953) Mar.

Questions by Garland M. Riegel, Republic Steel Corp., Massillon, Ohio.

1. Have you lined any acid tanks with Kel-F and how do you join sheets or plates of this material?
2. How resistant is Kel-F to 30 percent by weight nitric acid at 150-160 degrees F? To red fuming nitric acid at 90-110 degrees F?

Authors' Reply:

1. Liners for some highly corrosive applications have been fabricated by electronically sealing Kel-F film to proper dimensions for slipping into the container. Heavier sheets can be joined either by heat sealing methods or by use of hot air gun developed by DeBell & Richardson, Inc., Hazardville, Conn.
2. Kel-F is completely inert.

Question by C. W. McCutchen, Dow Chemical Co., Freeport, Texas:

Do you have any information on the corrosivity of liquid, gaseous or aqueous bromine (Br_2) on Kel-F, plasticized and unplasticized?

Authors' Reply:

Kel-F, plasticized and unplasticized is unaffected by gaseous or aqueous bromine.

Question by E. L. Rice, St. Louis, Mo.:

What experience have you had with Kel-F applications where continuous wear is experienced, such as sealing diaphragms on rotary seal members?

Authors' Reply:

No actual experience, but abrasive resistance of Kel-F is quite high, which would lead one to expect good service life for diaphragm rotary seal members.

The Corrosion Engineer Uses Plastics. By F. L. Whitney, Jr. *Corrosion*, Vol. 9, No. 4, 123-131 (1953) Apr.

Discussion by E. G. Holm, Tube-Kote, Inc., Houston, Texas:

I want to compliment Dr. Whitney on presentation of such a fine paper. To cover such a broad subject without presenting points of controversy, however, is impossible. Some controversy already has arisen over the presentation of three possible rules to fol-

low when contemplating thin films. I have specific reference to the statement that in combating "severe" corrosion, linings of $\frac{1}{8}$ -inch thickness or more should be employed.

"Severe" corrosion means many things to many people and the use of thick linings in combating corrosion of this rating is often unwise or impractical. In the chemical plant "severe" corrosion means rapid penetration of metal—often in a matter of days. Here the $\frac{1}{8}$ to $\frac{1}{4}$ -inch lining is desirable. In other industries such as in the production of oil and gas, a penetration which occurs in two or three years will be classed as severe. Comparatively speaking then, this is mild or moderate corrosion but because of economic reasons it rightfully is classed as "severe." Nevertheless an inert 5 to 8-mil film can and does afford excellent protection. There are many examples thin films will afford protection from corrosion classed as "severe."

Author's Reply:

Mr. Holm's point regarding the word "severe" corrosion is well taken and his interpretation is correct. With reference to corrosion in the chemical industry, the term "severe" applies to an environment in which a metal or alloy would have a short life, that is, on the order of days or weeks. There are, however, conditions in chemical plant operation where the term "severe" may not be employed correctly as to rapidity of failure, but rather to the magnitude of economic loss. For example, thin films may be useful in minimizing "severe" corrosion affecting steel surfaces exposed to water and fumes.

Discussion by Charles P. Dillon, Carbide & Carbon Chemicals Co., Texas City, Texas.

Mr. Whitney is to be congratulated for presenting a paper which summarizes so well those factors which should be considered in the selection and use of plastics in the corrosion field.

In the discussion concerning the addition of pigments, Mr. Whitney points out the aesthetic value as well as the light stability imparted by the pigmentation. To these factors we might well add the control of reflectance imparted and also, in some instances, an inhibitive effect on the underlying metal surface.

It has been pointed out that coatings of organic materials act as electrical insulating barriers against galvanic circuits arising from couples of dissimilar metals or from stray currents. By the same reasoning, I must disagree with the concept later stated about accelerated anodic dissolution at holidays in coatings. Because of the low permeability of plastic

coatings and their insulating properties, they will not act as cathodes to the bare metal exposed. Consequently, the corrosion at holidays in coatings is not analogous to that at holidays in coatings of metal cathodic to the base metal, e.g., copper or Monel cladding on steel.

The subject of the optimum thickness of coatings is so broad that generalizations are liable to numerous exceptions. It is my opinion that the requirement of one-eighth of an inch thickness is excessive. We have successfully used furfuryl and phenolic coatings, in services corrosive to the base metal, at thicknesses of less than fifteen mils. Indeed, baked-on coatings of the recommended thickness would be subject to cracking and spalling under conditions of thermal or mechanical expansion or contraction which would be readily withstood by the conventional thicknesses of 5-10 mils. It would seem that achieving the desired physical effects and an absolute minimum of holidays should be the criterion rather than any specific thickness.

Does the term "early failure" as applied to Figure 1 indicate some specific fraction of the anticipated life?

It is worth noting that there is, in the chemical process industry, a need for coating materials and for non-metallic materials of construction which would have good chemical resistance in the temperature range 200 to 300 degrees F.

Author's Reply:

The curve indicates that if a minimum thickness specification of two mils is made, the probability of obtaining useful protection from the available chemical resistant coatings and paints is only about 60 out of 100 or 60 percent. However, the curve would indicate that if a minimum specified thickness of six mils were employed, 90 out of 100 or 90 percent of the films employed would produce useful protection.

Probable performance is based on film penetration or failure at surface irregularities such as welds, projections and edges.

Discussion by Raymond B. Seymour, Atlas Mineral Products Co., Mertztown, Pa.

This paper should be a particularly valuable contribution since it is presented from the operating engineer's rather than a manufacturer's viewpoint. Whitney's, like all generalizations, will be criticized on the basis of exceptions rather than general utility and fortunately he has recognized this. For example, while some mineral acids in concentrations above 50 percent cause deterioration of Neoprene, this product is satisfactory at ordinary temperatures in the presence of 75 percent phosphoric acid and 70 percent sulfuric acid. Likewise, while phenolics and furanes are inherently brittle, this characteristic is not necessarily a function of polymerization. Unless compounded specifically for use with vegetable oils, natural rubber is not usually recommended for such service.

Some of the statements made throughout the article are almost important enough to be italicized since they are essentially axiomatic. Too much emphasis cannot be placed on some of these, such as: "plastics should be given the same consideration as metals and alloys," "the value of the material itself must be known to permit the proper evaluation," "never use a lining thickness of less than one-eighth inch," and "do not condemn a coating until the cause of failure has been thoroughly analyzed."

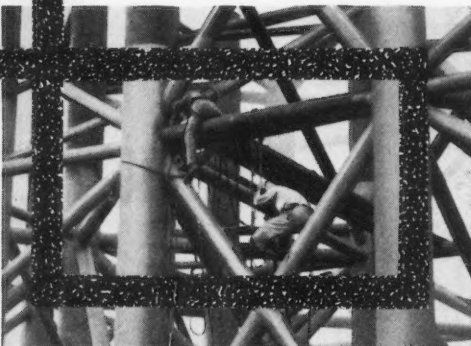
There is still a dearth of non-commercial articles on the chemical resistant properties of plastics used as materials of construction. Most of those that have been published have been primarily from the producer's viewpoint. More articles from the user's viewpoint are needed.



if this is your trouble...

Here is an off-shore drill structure located in the main pass of the Mississippi River. This installation was painted in June 1948 with three coats of oil-base marine paint. Note the condition, *only one year later!* The coating just couldn't take it!

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THE ANSWER?

Coatings based on VINYLITE Brand Resins applied to well structures, as shown in this photograph.

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Photos courtesy of Minnesota Mining & Manufacturing Company, Detroit 2, Mich., whose COROGARD coating system, using VINYLITE Resins as base, was used to coat the 10-well installation, and to repaint the structure where oil-base marine paint failed.

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Single-Package Wash Primers and Metal Conditioners

—Three new formulas for wash-primer metal conditioners provide unique advantages for industrial and other metal coating. In the past, the diluent and the base solution of wash primers were kept in separate packages. When mixed and ready for use, they were usable for about eight hours after mixing. Now, Formulas XE-5298, XE-5300, and XE-5368 are pre-aged, stable wash primers that can be ready-mixed in a single package without deterioration. Formula XE-5298 is based on XYHL, vinyl butyral resin, strongly adhesive with excellent resistance to water and sunlight. Formula XE-5300, based on XYHL, also contains basic zinc chromate for severest conditions. Formula XE-5368, especially recommended for use on steel for resistance to salt water, is based on VMCH. This vinyl-chloride-acetate resin also provides air-dry and low-bake adhesion.

Finishes to meet Federal Specifications

—Two new spar varnishes for specification TT-V-121c are among the many formulas based on BAKELITE and VINYLITE coating resins to meet latest government specifications. Both formulas, VF-1576 and VF-1586, are based on competitively-priced BR-9400 phenolic resin, noted for fast drying, water resistance and excellent durability. VF-1576 includes tung oil. VF-1586 is recommended where a tung-oil-free spar varnish is desired.

A great many other U. S. Government specifications call for coating products made from resins which are produced by BAKELITE COMPANY. Detailed information on specifications and formulations are kept continuously up-to-date by BAKELITE COMPANY for your assistance.

• For further facts about these resins and finishes, write Dept. PW-69, Bakelite Company, 30 East 42nd Street, New York, N. Y.

Topic of the Month

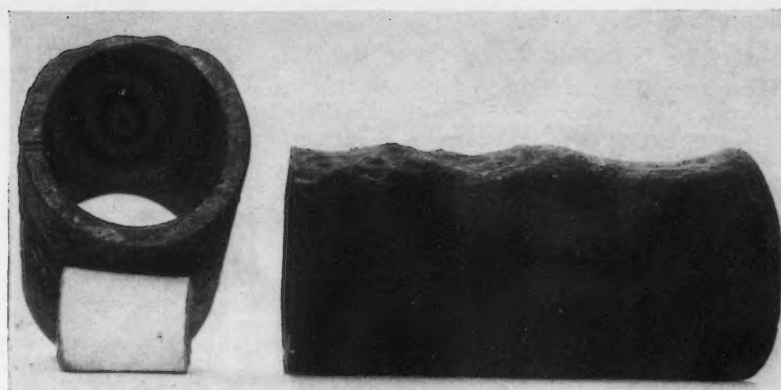


Figure 1—Two sections of 1 1/2-inch heating coil pipe. Attack can be seen along the top surface. The remainder of the pipe, both exterior and interior was in sound condition.

Scale vs. Bare Steel Potential Differences May Explain Unusual Tank Vessel Corrosion

By L. M. MOSHER*

Internal Corrosion of Tank Vessels

AN UNUSUAL type of localized corrosion attack has recently made its appearance on relatively new tank vessels in exclusive crude oil service, both coastwise and transoceanic. The fact that this occurs with crude oil service is noteworthy in that crude oil, even sour crudes, is not normally considered to be of serious corrosivity. It is of interest also that attacks of equivalent degree are being reported both by foreign and domestic tanker operators.

The writer has observed this corrosion on several vessels and finds that it appears as discrete pits or continuous chains of pits in the lower reaches of the cargo tanks and in every case on the top or exposed surfaces of the piping and structural members, e.g. heating coils, cargo lines, transverse and longitudinal members, etc. The accompanying photograph depicts this attack on the heating coils. That this attack is severe is attested by the fact that on the particular vessel from which these samples were taken, the heating coil piping of 3/16-inch wall thickness had suffered as many as twenty or more perforations per tank in a service life of about two and a half years.

In an attempt to find the cause of this corrosion, investigation was made of the many possible contributing factors such as type of cargo, ballast operations, relative times in cargo and in ballast, cleaning procedures, etc. Several of these factors appeared to be significant.

1. Serious pitting occurred in tanks alternately carrying cargo and ballast and not in tanks carrying cargo only. This indicated that the attack was associated with the sea water ballast phase.
2. A close inspection showed that pitting occurred not only on the top surfaces of the various mem-

bers described above but actually was oriented—attack was slightly to one side or the other of center, the nearest side—with respect to the location of the cleaning nozzles (these nozzles deliver revolving streams of high pressure, high temperature salt water which is used to clean the tanks between cargoes.) This established that the cleaning operation was tied in with the corrosive attack. **Note.** The fact that the pitting was confined to the lower part of the cargo tanks appears to be associated with the fact that this area is subject to the most vigorous cleaning.

3. Most severe attack occurred on vessels most frequently cleaned. In way of explanation, independent carriers because of change in cargo or change in ownership of cargo find it necessary to clean cargo tanks after practically every trip. By contrast, vessels on long term charter to a single oil company may find it necessary to clean only two or three times a year and then primarily to avoid build-up of heavy residues.
4. Maximum penetration of the pitting attack was 5/16-inch and this was observed in just under three years. In this respect, it should be noted that the ship's log showed that the service life was divided roughly into two-thirds time in cargo and one-third time in sea water ballast. It was apparent that corrosion of this degree was more severe than would be expected over such a relatively short period of time. This fact, along with the localized nature of the corrosion, suggested that some accelerated or galvanic factor was involved.

Two additional points interrelated with the above should be noted. Severe attack did not occur in cargo-carrying tanks subjected to the same cleaning schedule but not ballasted with sea water. This means, by inference, that neither cleaning per se nor the type of cargo per se is directly responsible for the attack.

*Central Technical Dept., Shipbuilding Division, Bethlehem Steel Company, Quincy, Mass. Transportation Industry Correspondent for CORROSION.

Scale vs. Bare Steel —

(Continued from Page 1)

With regard to the latter point, exception is made for the moderate corrosion usually experienced on tank bottoms exposed to crude oils, particularly sour crudes. This can be attributed to the settling out of moisture which usually is of acidic nature. However, attack of this type is usually more general and differs from the localized pitting attack under discussion.

Correlating the above observations, the writer considers the probable mechanism of attack to be as follows. Steel in tanker service is normally covered with scale—this can be mill scale at the outset but after varying intervals of service life may well be a combination of mill scale and/or rust scale which develops as a result of alternate exposure to cargo and ballast. Characteristic of such scaled surfaces are "breaks" in the scale which may be present at the outset or develop as a result of "working" of the vessel. When exposed to crude oil only or to alternate exposure of crude oil and sea water ballast without cleaning, such surfaces suffer no unusual corrosion. However, when these same surfaces are freed from protective oil or residues by cleaning, thereby exposing small areas of bare steel and large expanses of cathodic scale, and the tanks are then ballasted with sea water, galvanic attack occurs at the "breaks" in the scale as influenced by the surrounding areas of cathodic scale. In this latter respect, measurements showed substantial current flow between pits and

surrounding areas of scale, which bears out the galvanic nature of the attack.

In way of summary, it is suggested that the observed pitting attack occurs during the clean ballast period only and is accelerated by a galvanic couple between scaled and unscaled steel with the attack concentrated at the small anodic areas of bare steel.

NEXT MONTH

"Cooperative Effort in Corrosion Mitigation in Miami," by D. T. Rosselle, Southern Bell Telephone & Telegraph Co., Atlanta, explains the workings and results achieved by cooperative efforts in controlling underground corrosion. Mr. Rosselle, formerly at Miami, explains how the Greater Miami Corrosion Control Committee functions.

PAPERS APPROVED FOR PUBLICATION

Bacterial Corrosion of Offshore Structures by J. A. Caldwell and M. L. Lytle.

Graphical Multiple Correlation of Corrosion Data by O. B. Ellis.

References on Plastics for Corrosion Engineers by R. B. Seymour.

Selling a Corrosion Program to Management by F. L. Whitney, Jr.

• Papers on subjects of corrosion interest are accepted without invitation for review by the National Association of Corrosion Engineers. Write for a copy of the NACE Guide for the Preparation and Presentation of Papers, which gives details of the association's requirements.

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NACE News

Several TP Committee Chairmen Are Changed

Fritzlen and Skinner Accept Kansas City Symposium Posts

Glen A. Fritzlen, Haynes Stellite Division, Union Carbide & Carbon Corp., Kokomo, Ind., has accepted the chairmanship of the Elevated Temperature Symposium at the NACE Tenth Annual Conference and Exhibition. E. N. Skinner, Development and Research Division, The International Nickel Co., Inc., New York, has accepted co-chairmanship of the symposium. Mr. Fritzlen was co-chairman of the 1953 elevated temperature symposium at Chicago.

The Tenth Annual Conference and Exhibition will be held at Kansas City on March 15-19, 1954. F. L. Whitney, Jr., Monsanto Chemical Co., St. Louis, is technical program chairman.

Teche Section Meeting

Jerry Marshall, Chief Chemist, Texas Company Recycling Plant, Erath, La., discussed "Producing Well Corrosion Treatment" at a meeting of Teche Section April 14. The dinner meeting was held at Jacob's 4-Corner Restaurant, Lafayette, La.

Corrosion in Chemical Industry Is North East Region's Topic

A panel of four speakers will discuss "Corrosion in the Chemical Industry" at a meeting of North East Region to be held May 19 at Hotel Sheraton, Buffalo, N. Y. The sessions begin at 12:30 pm.

Speakers on the technical program include: M. G. Fontana, past-president of NACE, who will speak on "Corrosion in the Chemical Industry;" Allen L. Alexander, Protective Coatings Branch, Navy Research Laboratory, Washington, D. C., who will speak on "Application of Inhibited Pigments to Corrosion Control" and two other speakers to present discussions on metallizing and organic coatings.

Boston Section

Boston Section has scheduled tentative meetings on April 21, October 20 and December 1, 1953.

Important changes have been made in the make up of some NACE technical practices committees, a new committee has been added and one old committee dropped. R. C. Buchan, Humble Oil & Refining Co., Houston, is new chairman of Technical Practices Committee 1, with E. C. Greco, United Gas Corp., Shreveport, La., as vice-chairman. L. P. Sudrabin, Electro Rust-Proofing Corp., Belleville, N. J., is the new Technical Practices 4 chairman. New chairman of Technical Practices Committee 5 is Paul Gegner, Columbia Southern Chemical Corp., Barberton, Ohio. A. J. Lieberman, Dravo Corp., Pittsburgh, Pa., assumes the duties of vice-chairman of Technical Practices Committee 6.

The newly organized committee is Technical Practices Committee No. 5-D, "Corrosion by Organic Acids and Bases," with H. O. Teeple, International Nickel Co., Inc., New York, N. Y. as chairman. The committee which has been discontinued is Technical Practices Committee No. 10, "Corrosion Fatigue." H. W. Schmidt, Technical Practices Committee chairman said corrosion fatigue involving well sucker rods can be taken over by Technical Practices Committee No. 1-F, "Metallurgy—Oil and Gas Well Equipment," which has F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla. as chairman. Mr. Schmidt also said that if the need for investigation of corrosion fatigue arose in the future, a new committee could be formed.

The title has been changed for Technical Practices Committee No. 8. The new name is "Gulf Coast Cooling Waters." Charles P. Dillon, Carbide and Carbon Chemicals Co., Texas City, Texas, was appointed chairman with W. B. Brooks, The Dow Chemical Co., Freeport, Texas, vice-chairman.

TP-4 Is Reorganized Under Revised Rules

At a meeting in Chicago during the recent Ninth Annual Conference 40 persons, including 8 members of Technical Practices Committee 4 on Minimum Current Requirements for Cathodic Protection decided to collect and consolidate into a report information on the theoretical and practical aspects of establishing minimum current requirements for cathodic protection of structures. The committee, reactivated in accordance with an outline dated March 17, received information pertinent to the program from 15 members of NACE present. This information will be solicited in written or reprint form by the committee.

The committee's objective is to establish minimum current requirements for cathodic protection of steel, lead, alu-

(Continued on Page 4)

NOMINATIONS FOR 1954 NACE AWARDS

Should Be Made Not Later Than July 1

The Procedure for the Selection of Persons to Receive the Willis Rodney Whitney and Frank Newman Speller Awards in 1954 as approved by the Board of Directors in Galveston, March 14, 1952, provides for nominations being made by a local section or by an individual member directly to the Chairman of a Region. All nominations should be accompanied by an appropriate statement of the basis of the proposal.

This Procedure requires that prior to July 1, 1953, the Regional Chairman shall forward to the Chairman of the Awards Committee all names proposed for awards, accompanied in each case by summaries of the reasons presented in support of each proposal, but with no indication of the number of duplicate nominations of any individual. The object of this latter provision is to insure that awards will be made on a basis of accomplishments and

other qualifications rather than by any semblance of a popular vote.

The Procedure also requires that the NACE membership be notified of their privileges with regard to nominating candidates for these awards either by direct letter not later than May 1, 1953, or through publication in the May, 1953 issue of CORROSION. A direct letter is not contemplated; hence, this notice as it appears in this issue of CORROSION Magazine will serve as the notification to the NACE membership that nominations for these two awards may be made to their respective Regional Chairman not later than July 1, 1953. Reference to the Regional Division map on page iv and the Directory of Regional and Sectional Officers on pages iv and v of this issue will enable any member to obtain the name and mailing address of the regional chairman to whom his nominations should be sent.

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Hamilton-Niagara Section Set Up in Canada

Surface Preparation Report Is Published

With the publication in this the May, 1953 issue of Corrosion of the Second Interim Report of Technical Practices Committee 6-G on Surface Preparation of Steels for Organic and Other Protective Coatings, the committee has outlined two new projects. A. J. Liebman of Dravo Corp., Pittsburgh, chairman of the committee reported that the group has already started studying requirements for surface preparation of non-ferrous metals.

Meetings have been held and a preliminary outline of work has been drafted to cover two items for consideration: a) Aluminum and Its Alloys and b) Magnesium and Its Alloys. The committee plans to issue separate reports to cover each of these items. These reports will be followed by others on other non-ferrous metals.

Newell Is Elected

Thomas M. Newell, Cardinal Chemical, Inc., Odessa has been named chairman of Permian Basin Section. Other officers named were E. O. Kemper, first vice-chairman, Permian Enterprises, Inc., and William A. Hopwood, second vice-chairman, Trueme Company, both of Odessa and John A. Knox, The Western Co., Midland, secretary-treasurer.

REPRINT

Publication 53-1
**Surface Preparation
Of Steels
For Organic and
Other Protective Coatings**

• Second Interim Report of NACE
Technical Practices Sub-Committee
6-G on Surface Preparation for
Organic Coatings.

This report itemizes the various procedures used to prepare steels for the application of protective coatings. Recommendations as to procedures, standards, safety measures are given. This second report by NACE TP-6G is the culmination of many months of work by committee members. The report has been carefully prepared and checked by committee members with long experience in the coatings application field.

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Canadian Regional Division of NACE has accepted the petition of Hamilton-Niagara Section to be recognized by NACE. C. E. Makepeace, Page Hersey Tubes, Ltd., Welland, Ont., is section chairman.

T. B. Watson, of Corrosion Service Ltd., Toronto has been notified by G. M. McPherson, Canadian Region secretary-treasurer that the regional board has accepted the Toronto Section's petition for recognition as an NACE section.

T. R. B. Watson of Corrosion Service, Ltd., Toronto has been elected chairman of the new Toronto Section in Canadian Region. Also elected were Colin Prescott, Hydro-Electric Power Commission, vice-chairman; R. J. Law, The International Nickel Co. of Canada, Ltd., secretary and Stephen Kozak, Canada Wire & Cable Co., treasurer. All are of Toronto.

Holiday Detectors Is Topic at San Francisco

John P. Rasor of Tinker & Rasor, spoke on "Construction and Use of Holiday Detectors" at a meeting of San Francisco Section April 8. The dinner meeting, held at Alouette Restaurant, San Francisco, was attended by 17 members and 15 guests.

Mr. Rasor described the various types of electronic instruments available for the detection of coating flaws on pipe lines. The various power sources in common use and the limitations and advantages of each were discussed. Mr. Rasor called for a better understanding of the role of detectors, for better specifications for their selection and for greater care and supervision in their use. He demonstrated how coating flaw detectors operate. A lively discussion followed his talk and instruments on display were examined.

TP-4 Is Reorganized—

(Continued from Page 3)

minum and other metals in a variety of corrosive environments by

- Defining the condition of satisfactory protection.
- Comparison of the methods of measuring such a condition.
- Evaluation of the effects of environment and special relationships.

The compiled digest will be distributed to members before the committee's next meeting for review prior to preparation of an interim report. The committee also hopes to define more accurately the scope of its work.

The preliminary report of A. V. Smith on the questionnaire sent to NACE members requesting information on whether or not there was any proved method to determine and test the effectiveness of cathodic protection will be reproduced and sent to committee members.

Indices to each volume of Corrosion are published in the December, the twelfth and last issue of each year.



NACE MEETINGS CALENDAR

May

- 7—Pittsburgh Section. Corrosion of Radiant Heating Systems.
- 8—Philadelphia Section. Poor Richard Club.
- 12—Houston Section. Founder's Night Program. Kelley's Restaurant, Houston.
- 15—Jacksonville, Fla. Section.
- 19—Shreveport Section. Corrosion Experiences with Steel and Cast Iron Pipe, by Sidney E. Trouard, New Orleans Public Service Corp.
- 19—Cleveland Section. Plant tour, Loysys Brewing Co., Cleveland.
- Chicago Section. Round table discussion on protective coatings.
- 20—Los Angeles Section. Dinner meeting.
- 26—Southwestern Ohio. Activities at Fernald, by Wm. E. Shaw, department head, National Lead Company of Ohio.

June

- 3—Southern New England Section.
- 19—Shreveport Section. A Talk by R. L. Bullock, Interstate Oil Pipe Line Co., Shreveport.

Regional Meetings

Regional meetings of the National Association of Corrosion Engineers have been scheduled as follows:

May

- 7—South East Region. Chattanooga, Tenn. Patten Hotel.
- 19—North East Region. Buffalo, N. Y., Hotel Sheraton.

Oct.

- 7-9—South Central Region. Tulsa, Okla., Mayo Hotel.
- 7—North East Region. New Haven, Conn.

Two Discussions Heard By Los Angeles Section

Two technical discussions were heard by members of Los Angeles Section at a dinner meeting April 1 at Rodger Young Auditorium Los Angeles. There were present 73 members and guests.

E. O. Kartinen of Signal Oil and Gas Co., spoke on "Effects of Corrosion and Erosion on Some Steel Piers Along the Southern California Coast," while J. T. Gow of Electric Steel Foundry Co., spoke on "Resistance of Cast Iron-Chromium-Nickel Alloys to Corrosion in Oxidizing and Reducing Flue Gas Atmospheres."

K. T. Vangsnes, retiring chairman, introduced new officers, S. J. Artese, chairman; S. K. Gally, vice-chairman and E. H. Tandy, secretary-treasurer.

Cavanagh Is Elected

W. R. Cavanagh, Parker Rust Proof Company, Detroit, Mich., has been elected to serve a three year term as chairman for North Central Region, National Association of Corrosion Engineers. He succeeds F. L. Whitney, Jr., Monsanto Chemical Company, St. Louis, whose term expired in March. As chairman he is a director of the association.

Trouard Will Address Shreveport Section On Pipe Corrosion

"Corrosion Experiences with Steel and Cast Iron Pipe in the New Orleans Area" will be the subject for the technical program for the Shreveport Section meeting, May 19. The speaker will be Sidney E. Trouard of the New Orleans Public Service, New Orleans, La.

Technical speaker for the June 16 meeting will be R. L. Bullock of Interstate Oil Pipe Line Co., Shreveport, La. Subject for his talk was to be announced later. All meetings of the Section are held at the Caddo Hotel, Shreveport, La.

Shreveport Section has scheduled programs as follows:

April 21—Oil and Gas Well Corrosion by W. J. Stewart, Sun Oil Co., Beaumont, Texas.

May 19—Corrosion Experiences with Steel and Cast Iron Pipe in the New Orleans Area by Sidney E. Trouard, New Orleans Public Service Corp., New Orleans.

June 16—A talk by R. L. Bullock, Interstate Oil Pipe Line Co., Shreveport.

R. C. Jordan, United Gas Pipe Line Co., has been named secretary of Shreveport Section.

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3-Day Short Course Scheduled at Wisconsin U.

A three-day Corrosion Control Institute will be held May 19-21 inclusive at the University of Wisconsin, Madison. The institute is being conducted by the University Extension Division, and College of Engineering with the cooperation of Eastern Wisconsin Section NACE.

The program is designed to interest persons charged with the design, operation and maintenance of systems subject to corrosion. Types of corrosive action will be defined and mechanics of processes discussed. Information on control

practices and techniques will include testing, evaluation, predication of rates, selection of materials, cost accounting, aspects of cathodic protection and protective coatings. Registration fee is \$20, payable to University of Wisconsin. Housing in Madison hotels and meals must be arranged for by registrants.

All sessions will be held in Room 2016 of the Electrical Engineering Building, off Randall Ave. at the end of West Johnson St., Madison. A certificate will be given each person attending

all sessions who satisfactorily completes the course.

The program was as follows:

Tuesday, May 19

- 8:30 am to 9 am—Late Registration and Mixer. Room 2016, New Engineering Bldg.
- 9 am—Welcome, Paul J. Grogan, Director of Engineering Institutes, University of Wisconsin.
- 10 am—Fundamentals of Corrosion, Prof. Wayne K. Neill, Dept. of Chemical Engineering, University of Wisconsin.
- 11:30 am—Group photograph.
- 12 noon—Lunch.
- 1:30 pm—Test Procedures and Evaluation, Dr. H. F. Haase, Corrosion Consultant, Milwaukee.
- 2:45 pm—Break period.
- 3 pm—Test Procedures and Evaluation, contd. Dr. Haase.
- 4:30 pm—Adjourn until 7 pm.
- 7 pm—Dinner meeting, Rohde's Steak House, 613 West Main St., charge \$3.50. 1953 Rose Bowl Game motion pictures. "The National Association of Corrosion Engineers," by Robert Wicen, chairman, Eastern Wisconsin Section NACE.

Wednesday, May 20

- 9 am—Materials of Construction—Ferrous. Speaker to be announced.
- 10:15 am—Coffee stop.
- 10:30 am—Materials of Construction—Non Ferrous, Dr. C. L. Bulow, Bridgeport, Brass Co., Bridgeport, Conn.
- 12 noon—Lunch.
- 1:30 pm—Materials of Construction—Non Metallic by Prof. Roland Ragatz, Dept. of Chemical Engineering, University of Wisconsin.
- 2:30 pm—Surface Preparation, A. J. Liebman, Dravo Corp., Pittsburgh.
- 3:30 pm—Protective Coatings—Organic and Metallic, R. M. Burns, Bell Telephone Laboratories, Murray Hill, N. J.
- 4:50 pm—Adjourn.

Thursday, May 21

- 8:30 am—Cathodic Protection—Part I, Galvanic. Speaker to be named.
 - 9:30 am—Cathodic Protection—Part II, Impressed, L. H. Sudrablin, Electro Rust-Proofing Corp., Belleville, N. J.
 - 10:30 am—Coffee stop.
 - 10:45 am—Control of Environments—Inhibitors. Speaker to be named.
 - 11:30 am—Corrosion Question Board. All speakers to comprise panel.
 - 11:45 am—Presentation of Certificates. Prof. D. J. Mack, Dept. of Mining and Metallurgical Engineering, University of Wisconsin.
- Last minute additions to the program are:

Cathodic Protection—Part I, Galvanic. R. F. Featherly, Cathodic Protection Engineer, Dow Chemical Company, Midland, Mich.

Materials of Construction—Ferrous. R. B. Hoxeng, Research Associate, U.S. Steel Corp., Pittsburgh.

Control of Environment—Inhibitors. Joe Surcek, Technical Service Dept., Dearborn Chemical Company, Chicago.

Some Problems in the Long-Term Packaging of Metal Parts. V. W. Meloche, Professor of Chemistry, University of Wisconsin.

Case Studies from Research and Industry. Prof. D. J. Mack, Dept. of Mining and Metallurgical Engineering, University of Wisconsin.

NACE Is Looking For a Copy of Soil Corrosion and Pipe Line Protection

By SCOTT P. EWING

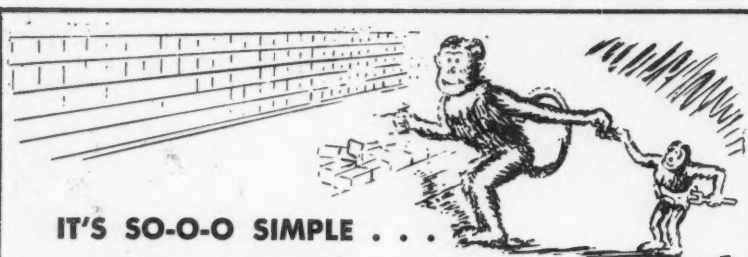
This book was published by the American Gas Association in 1938, and the NACE Central Office wants a copy for the library. In exchange for a copy of Mr. Ewing's book, the Central Office will give any one of the following:

Cathodic Protection—A Symposium

Bibliographic Survey of Corrosion—1945

Bibliographic Survey of Corrosion—1946-47.

Anyone wishing to exchange a copy of the Ewing book, please contact A. B. Campbell, National Association of Corrosion Engineers, 1061 M & M Building, Houston 1, Tex.



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Houston Section Plans Long-Range Activities

Before the election ballots got cold, new officers of the Houston Section under the direction of chairman L. G. Sharpe, Humble Pipe Line Co., Houston, started planning activities and projects. Some activities are already underway, some arrangements are tentative.

"Charles Gribble and G. L. Doremus worked successfully to make the Houston Section stronger," Chairman Sharpe said, "and we believe that with the cooperation of the members we can continue to build," he continued. Mr. Gribble was chairman for 1952 and Mr. Doremus was secretary-treasurer.

To plan programs with the strongest possible appeal to members, F. W. Gartner, Jr., of the F. W. Gartner Co., Houston and Ray Cherry, Monsanto Chemical Co., Texas City, made a survey of company affiliations of all Houston Section members.



Nathan

Classifications Given

Classified by type of work done, 114 members are in the chemical industry, 162 in the petroleum industry, 79 in the metals industry, 62 in non-metallic industries, 97 in the paint industry and 221 listed in occupations which provide service to other industries, such as consulting engineers and utility companies. In most cases, each member works in more than one field. A questionnaire asking members to state their preference as the kind of program they would like was scheduled to be mailed the first of May.

At the April meeting, Dr. C. C. Nathan of the Texas Company spoke on "Studies on the Inhibition by Amines of the Corrosion of Iron by Solutions of High Acidity." Using atomic models which could be disassembled and reassembled to show various molecular structures, Dr. Nathan showed members how some amine compounds, because of their molecular structure, adsorb closely to metal surfaces. By building models of other amine molecules, he demonstrated how some of these compounds were less suitable as inhibitors. By using the models and by clear presentation, Dr. Nathan was able to explain results of experiments and intricate theories.

Studies Are Described

He described studies carried out on the corrosion of both steel strips and iron powder in solutions of 1 normal hydrochloric acid. These studies have been directed toward evaluation of various aliphatic and aromatic amines as corrosion inhibitors and to the correlation of the structure of the amines with their adsorption characteristics and inhibition efficiencies.

Dr. Nathan found that the effectiveness of the amines increases with molecular weight in a homologous series and that steric factors which would appear to be more favorable for the adsorption of the amine or its ion at the metal to solution interface increase the inhibition efficiency. These factors were discussed

in detail. The series of amines investigated were the aliphatic straight and branched chain, aniline and its homologs, and N-alkylated derivatives, alkylated pyridines and pyridine homologs and several dibasic aromatic amines.

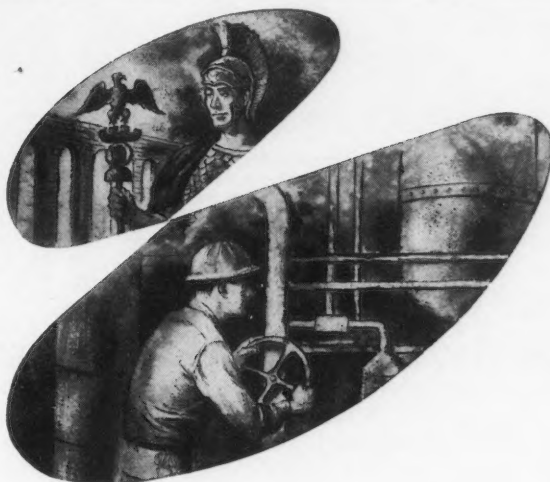
Since 1948 Dr. Nathan has been engineer in research and corrosion and other production problems at the Texas Company Producing Department Laboratory in Bellaire, Texas.

Social Meeting Planned

The next section meeting was scheduled for May 12, as a social meeting at San Jacinto Inn with wives and friends invited and with a minimum of speech making.

Tentative programs for next Fall as outlined by W. B. Brooks, Dow Chemical Co., Freeport, Tex., program chairman, include a Student Night, when students from universities and colleges in the area will be invited to attend a regular section meeting. Subject for the technical portion of this program, Fundamentals of Corrosion, would be of interest to members and also to the attending students. Both theory and practice will be explained.

Another likely program for the Fall is a Founder's Night meeting where veterans who organized NACE and were prominent in early Houston Section activities would be invited as guests of honor.



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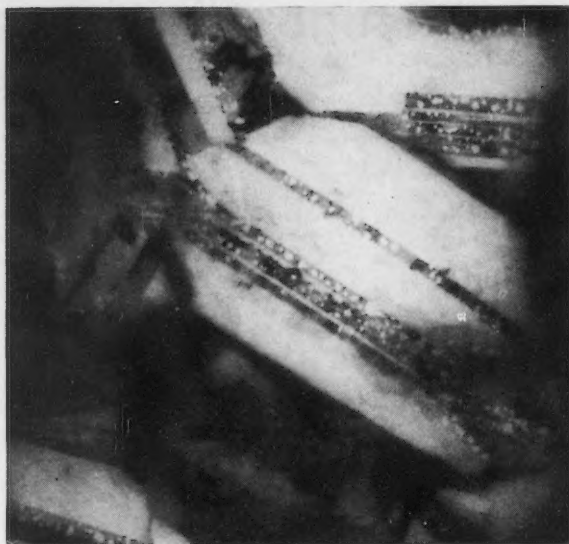


Figure 1—Electron micrograph showing the crystal structure in electro-deposited nickel from a Watts-type plating bath. This micrograph was obtained at the National Bureau of Standards by transmitting an electron beam through nickel deposited as a film one-millionth of an inch thick. (Approx. $\times 25,200$.)

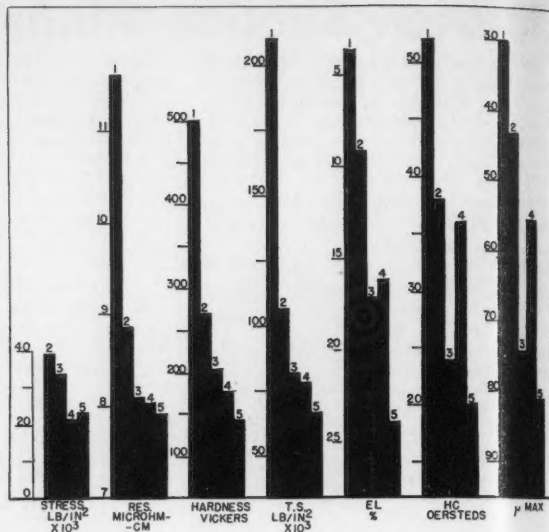


Figure 2—Block diagram summarizing data obtained by the National Bureau of Standards on the physical properties of nickel deposited from five different types of plating baths. 1. Bright-nickel bath. 2. High-chloride bath. 3. Bath containing half the nickel as chloride and half as sulfate. 4. Sulfate bath. 5. Watts-type bath.

Properties of Electrodeposited Nickel *

AMUCH CLEARER picture of the effect of plating variables on the structure and properties of electrodeposited nickel has resulted from a comprehensive laboratory investigation¹ conducted over the past five years by Victor Zentner, Abner Brenner and Charles Jennings of the National Bureau of Standards. In the course of the study, which was sponsored by the American Electroplaters' Society, cathode current efficiencies and the internal stress of the deposits were determined for a great number of different bath compositions and operating conditions, the chemical composition and microstructure of the deposits were investigated and their thermal and mechanical properties were measured. The results show that hardness, tensile strength and other properties of nickel deposits can be varied over a wide range by proper choice of plating bath. Moreover, it has been possible to explain this broad variation in properties on the basis of the physical nature of codeposited impurities present in small amounts.

Industrial use of nickel plating includes a variety of applications. In general, the thinner coatings are used for ornamental purposes or for protection against corrosion while the heavier deposits are applied to machine parts, where resistance to wear is an important factor and used in electroforming. Although quite different properties are required in different applications, until now little information has been avail-

able regarding the relationship between the conditions under which the plating is done and the resulting deposit. The NBS investigation provides a large amount of basic data which can now be utilized for the consistent production of deposits having desired properties. While major emphasis was placed on those mechanical properties of the deposits which are of immediate value in engineering applications, data were also collected on electrical and other properties which may be of value in determining the suitability of nickel deposits for special applications.

240 Deposits Produced

In the NBS study, about 240 different deposits were produced from 20 different types of baths operated over a wide range of temperature, current density and pH. The test specimens were obtained by depositing nickel on sheet or tubular cathodes to a thickness of about 0.01 inch. During the plating process, current efficiencies and internal stress of the deposits were measured. After separation from the cathodes, the specimens were analyzed chemically and their structures were studied by optical microscopy, electron microscopy (Figure 1), and X-ray diffraction. They were also tested for hardness, tensile strength, elongation, yield strength, Young's modulus of elasticity, fatigue limit, internal friction, thermal expansion, specific heat, heat of solution, electrical resistivity and magnetic properties. The effects of heat treatment on many of these properties were studied.

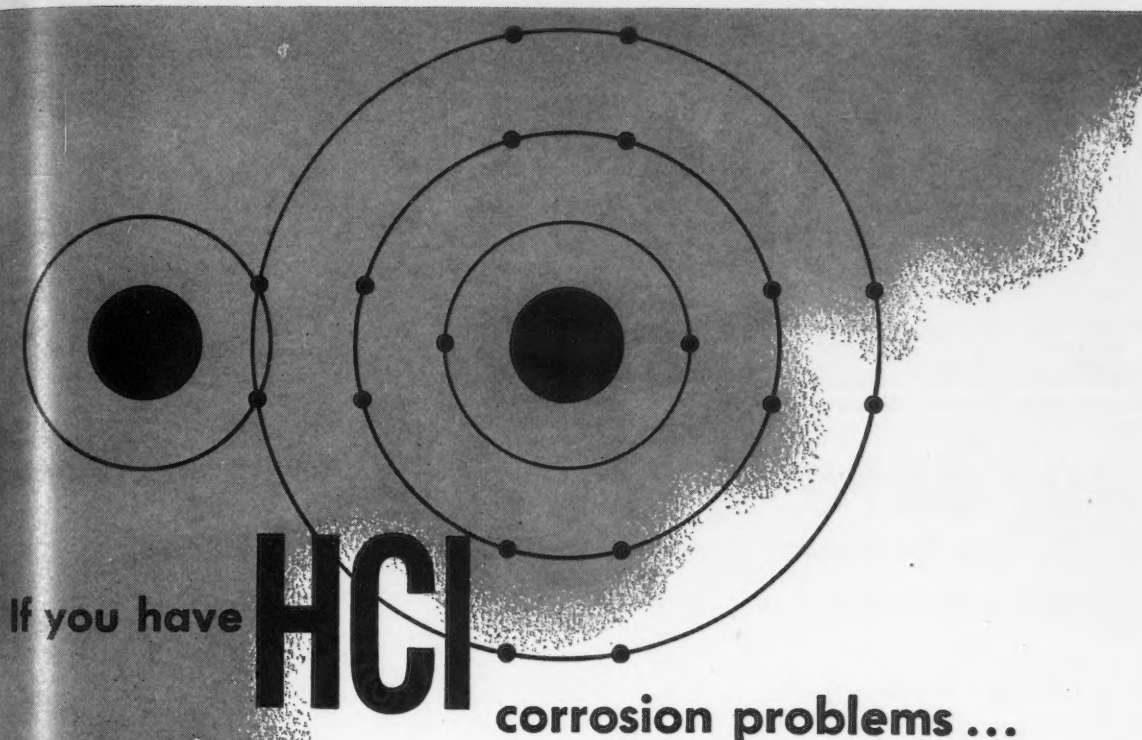
It was found that the most important factor affecting the properties of the deposits is the type of plating solution,

that is, the nature of the anion and the presence of special additives. Although deposits produced at lower temperatures were usually finer-grained than those obtained at high temperatures, the effects of variations in operating conditions, such as temperature and current density, are in general relatively small, provided the conditions are within the satisfactory operating range for the solution used.

On the basis of the physical and mechanical properties of the deposits, nickel plating baths may be classified in three main groups: *bright-nickel* baths, containing organic brighteners; *high-chloride* baths, containing more than 50 percent of the nickel present as chloride; and *Watts-type* baths, which contain the nickel in the form of both sulfate and chloride in the ratio of 3:1. In general, the extremes in properties are shown by the bright-nickel and the Watts-nickel deposits while the properties of the high-chloride nickel are intermediate between the two (Figures 2 and 3). The bright-nickel baths yield bright deposits having the greatest hardness, tensile strength, resistivity and coercive force of all types of nickel deposits, but they also have the lowest ductility, elongation and magnetic permeability. The high-chloride baths, on the other hand, produce dull deposits which are somewhat below bright nickel in hardness and tensile strength but have a higher ductility. From the Watts-type baths are obtained dull grey deposits. These are the purest of the three types; they possess the lowest stress, hardness, tensile strength, resistivity and coercive force and at the same time the highest

(Continued on Page 10)

* For further details see *The Effect of Plating Variables on the Structure and Properties of Electrodeposited Nickel* by Victor Zentner, A. Brenner and C. W. Jennings. *Plating*, 39, 865 (1952).



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HOT DOPE

Straight from the Kettle
on PIPE PROTECTION

By Boyd Mayes

•A guy we know recently spent more time than we had to spare telling us that everything was going to pot. Well, he didn't make much of an impression because we are inclined to agree with Judge Harold R. Medina in his story that named cynicism as Public Enemy No. 1. "Cynicism" . . . that's a fancy word for an East Texas country boy to understand, but we've got horse sense, and horse sense can figure out people who go around knocking everything, including the chance to succeed. Regardless of all the confusion involved in doing business . . . and in just plain living . . . today, we somehow still believe there are more smart people than there are dumb people in America, and that we're going to come out all right, despite all cynical palaver going the rounds. Truth of the matter is, we'd better believe things are going along all right in our chosen land. We've got about a million bucks socked into physical properties . . . land, plants and equipment . . . and an equal amount in a staff of the world's finest coating and wrapping craftsmen . . . plus a list of satisfied customers too long to name right off hand, depending on us to dependably clean, coat and wrap their pipe to deliver gas and oil to their many millions of customers. Frankly, we don't think business . . . in our country . . . is doing badly!

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Properties of—

(Continued from Page 8)

ductility, elongation and magnetic permeability.

Chloride Content Critical

The properties of the deposits were affected very little by the concentration of nickel in the plating solutions. However, the effect of the chloride content of the bath on the hardness of the deposit was rather striking (Figure 4). When a bath containing one-fourth of the nickel in the form of chloride and the rest as sulfate was used, a pronounced minimum in hardness of the deposit was observed. As yet no explanation for this effect has been developed.

In its influence on the mechanical properties of the deposits, the pH of the plating solution was second in importance only to the nature of the bath constituents. In the pH measurements, it was found that when the pH of the bath goes above 5, the tensile strength

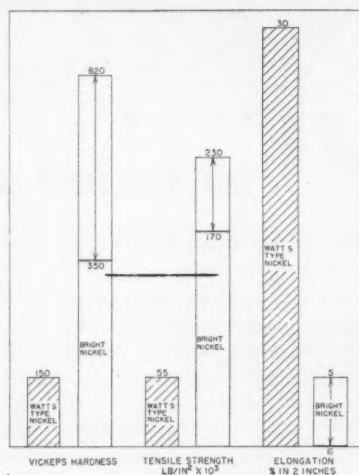


Figure 3—Graphical comparison of the mechanical properties of nickel deposits obtained from Watts-type and bright-nickel plating solutions. The arrows show the range over which the bright-nickel deposits vary.

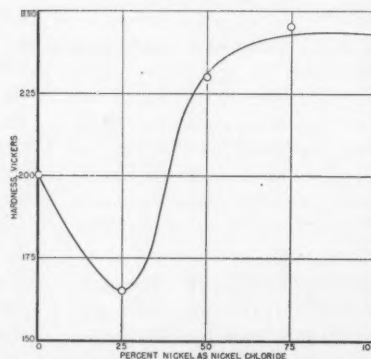


Figure 4—Effect of the chloride content of the plating bath on the hardness of nickel deposits. Each point represents the average hardness of five to ten deposits, each produced under different plating conditions in the National Bureau of Standards electrodeposition laboratory. No explanation for the pronounced drop in hardness at 25 percent chloride content has been found.

of the deposit rapidly rises and the ductility decreases (Figure 5). If the pH of the solution is made high enough, there is a marked increase in hardness and tensile strength and a decrease in elongation. However, these extreme properties are accompanied by such a

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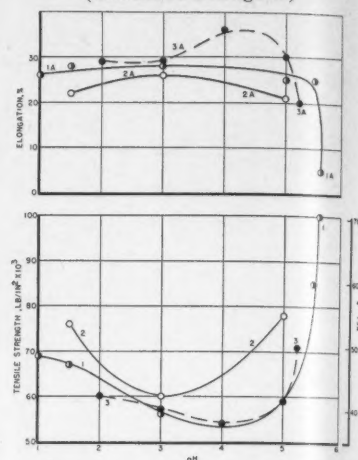


Figure 5—Effect of the pH of the plating bath on the tensile strength and elongation of nickel deposited at 2 and 5 amp/dm². Curve 1. Watts bath at 55° C. Curve 2. Modified Watts bath at 30° C and 55° C. Curve 3. Composite curve from data obtained by Gardam, Macnaughton and Roehl.

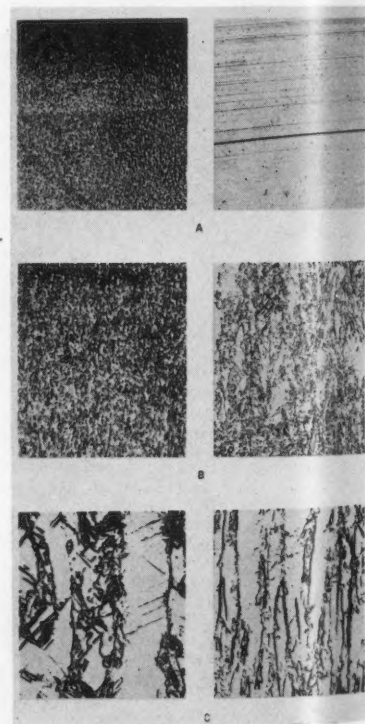


Figure 6—Microstructure of typical nickel deposits obtained at the National Bureau of Standards from: A—Bright-nickel plating baths. B—High-chloride baths. C—Watts-type baths. In general, it was found that the more fine-grained deposits (A) have greater hardness and tensile strength. (Approx. x 140.)

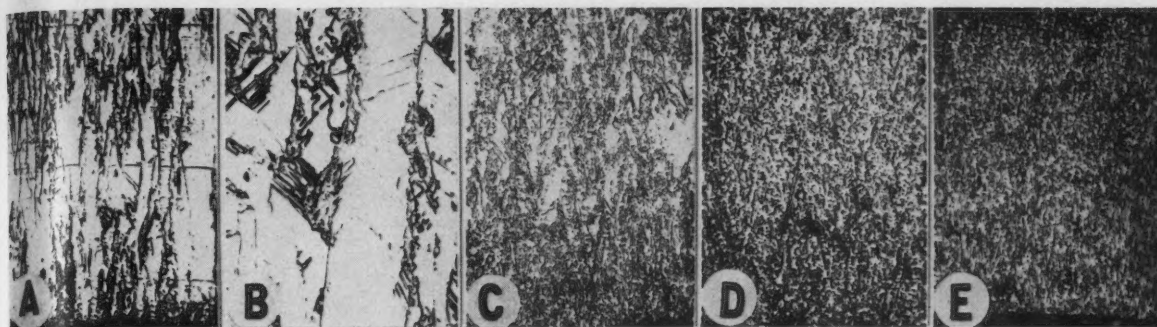


Figure 7—Micrographs showing the effect of increasing chloride content in the plating bath on the structure and hardness of electrodeposited nickel. In A, the plating bath contained no nickel chloride; all the nickel was in the form of sulfate. The other baths contained 25 percent chloride (B), 50 percent chloride (C), 75 percent chloride (D), and 100 percent chloride (E). In each case the remainder of the nickel was present as sulfate. As the more fine-grained deposits have been found to be harder, it is evident that the 25-percent chloride bath (B) produces the deposit of least hardness. The deposits were obtained at a temperature of 55° C, a current density of 5 amp/dm², and a pH of 3.0. (Approx. x 250.)

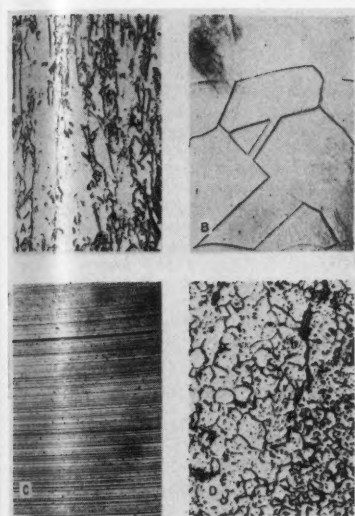


Figure 8—Microstructure of nickel deposits before and after heat treating. A: Watts nickel as deposited. B: Watts nickel heat-treated at 1000° C. C: Bright nickel as deposited. D: Bright nickel heat treated at 1000° C. The dark areas in the heat-treated bright nickel may indicate either voids or inclusions. (Approx. x 250.)

Properties of—

(Continued from Page 10)

great increase in stress that the deposits are likely to crack spontaneously or exfoliate.

The microstructure of the deposits was rather closely correlated with their observed properties (Figure 6 and 7). Thus, in micrographs of nickel deposits from baths of varying chloride content, the most coarse-grained deposit had the lowest hardness. In general, deposits with coarse-grained structures contained relatively small amounts of impurities and were soft, ductile and low in tensile strength. On the other hand, deposits with either fine-grained structures or no visible grain structures contained a relatively large amount of impurities and were strong and hard but not very ductile.

Heat treatment was found to have a much more pronounced effect on the

(Continued on Page 12)

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Properties of—

(Continued from Page 11)

mechanical properties of bright nickel than on those of Watts nickel (Figure 8). Thus, after heat treatment at 400° C, the tensile strength of bright nickel fell from about 200,000 lb/in.² to about 20,000 lb/in.² By contrast, the tensile strength of Watts nickel decreased by only 15,000 lb/in.² from an initial value of 75,000 lb/in.² A comparison of the microstructures of the two types of deposits shows large clean grains in the Watts nickel while the bright nickel deposits have dark areas which may indicate either inclusions or voids.

Impurities Set Quality

On the basis of the data obtained in the investigation, it appears that the widely varying properties shown by electrodeposited nickel are determined primarily by the chemical and physical nature of codeposited impurities—usually small quantities of oxygen, hydrogen, carbon, or other elements present in small fractions of a percent. This is shown not only by the parallel trend in the variation of many of the properties, indicating a common basic cause, but also in the correlations found between properties and crystal or microstructure and in the pronounced dependence of the properties on bath composition. Because large changes in the deposits result from the presence of certain types of ions or minute amounts of special additions to the plating bath, it is reasonable to assume that the distinctive character of the deposits is caused by the codeposition of various kinds of foreign matter which may vary in quantity as well as in effectiveness. The codeposited material may sometimes influence the properties of the deposit directly; in other cases, it may result in a fine-grained structure, perhaps with lattice distortion and internal stresses, which in turn affects the physical and mechanical properties of the deposits.

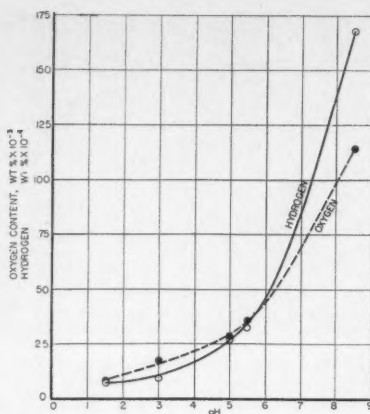


Figure 9—(Graph) Effect of pH of plating bath on the oxygen and hydrogen content of nickel deposits from data obtained at the National Bureau of Standards. As the tensile strength of nickel deposits has also been found to increase with pH, a close correlation apparently exists between mechanical properties of deposits and their oxygen content. This relationship lends support to the Bureau's hypothesis that the properties of an electrodeposit are determined primarily by the nature of codeposited impurities. Each point is an average value for 26 deposits, obtained from 10 different solutions at various temperatures and current densities.

In general, it would seem that substances present in the plating solution affect the properties of the electrodeposit only to the extent that they influence the codeposition of foreign material. Thus, the great differences in the properties of bright-nickel and Watts-nickel deposits can be ascribed to impurities in the bright nickel derived from the organic additives used to produce the brightening. In fact, the Bureau's analysis of the bright-nickel deposits showed that they contained carbon and sulfur inclusions totalling about 0.1 percent,

whereas the Watts-nickel deposits did not contain these impurities. On the other hand, some of the variations in the mechanical properties of the Watts-nickel deposits can be attributed to the presence of small amounts of oxide. For example, a good correlation was found to exist between the mechanical properties of Watts-nickel deposits and their oxygen content.


It thus becomes apparent that those electrodeposited coatings that are of value in industry are not pure coatings, but owe their valuable properties to the presence of small amounts of impurities. The smooth, thick electrodeposits used by the plating industry are actually exceptional inasmuch as the pure metals would be deposited as a mass of large crystals rather than a coherent layer.

The mechanism by which foreign material is codeposited with nickel is a matter of speculation, but the NBS study indicates that it is probably an adsorption phenomenon rather than an electrochemical one, as has sometimes been postulated. The adsorption hypothesis is sufficiently versatile to explain the very specific effects of certain additives and the influence of the anion of a plating solution on the nature of the deposit. Some substances, instead of being directly adsorbed, may so modify the pH of the cathode film that basic compounds are codeposited with the metal. Further research is needed on adsorption phenomena and the processes taking place in the cathode film during electrolysis. More precise methods of analysis will be required in order to correlate the content of foreign material with lattice distortion and crystal structure.

Speedier Review of Manuscripts Planned

The Editorial Review Committee of the National Association of Corrosion Engineers took steps at a meeting March 16 at Chicago to further speed the review of technical manuscripts presented for publication in *CORROSION*, the association's monthly magazine. Meeting under the guidance of George Diehlman, of National Lead Co., New York City, retiring chairman, the committee decided to request that authors supply three copies of all papers submitted for review. This would enable the committee to send out copies simultaneously to two reviewers and speed up decisions on the papers.

There was present at this meeting two of the new members of the committee, Messrs. V. B. Pike, Bell Telephone Laboratories, Murray Hill, N. J., and J. J. Harwood, Office of Naval Research, Navy Dept., Washington, D. C. Mr. Diehlman, retiring chairman, agreed to remain active on the committee for another year. This will mean the committee now consists of, in addition to those mentioned, Thomas P. May, The International Nickel Co., Inc., New York City, chairman; J. W. Ryznar, National Aluminate Corp., Chicago; I. C. Dietze, Department of Water and Power, Los Angeles; and Arthur W. Tracy, American Brass Co., Waterbury, Conn. Mr. Tracy was unable to attend the Chicago meeting. Mr. Dietze, while in Chicago, was unable to attend the committee session because of a technical committee meeting.



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Camden A. Coberly Is Elected at St. Louis

Camden A. Coberly of Mallinckrodt Chemical Works, St. Louis, will take office as chairman of Greater St. Louis Section NACE at the close of the section's May meeting. Elected at the same time as Dr. Coberly, at the April 13 meeting of the section were: William J. Ries, Tretolite Company, vice-chairman; Robert D. Sanford, Nooter Corp., secretary and Donald H. Becker, Reilly Tar & Chemical Co., treasurer. Elected to the section board were F. L. Whitney, Jr., Monsanto Chemical Company and William E. Kleefisch, Nooter Corp. All officers are of St. Louis.

The April 13 dinner meeting was attended by 42 members and guests. T. E. Larson, head of the chemistry subdivision, Illinois State Water Survey Division, Urbana spoke on "Corrosion—A Water Quality Problem." Problems in corrosion encountered in water treatment, sewage and waste disposal were discussed by Dr. Larson.

Gordon Conference on Corrosion Scheduled

"A Critical Review of Modern Fundamental Concepts in Corrosion" will be the subject of a five-day Gordon Research Conference to be held at Colby Junior College, New London, N. H., Monday through Friday, July 20-24, 1953. Topics to be discussed and dates are:

July 20

Thermodynamics in Corrosion.
Electrochemical Theory of Corrosion.

July 21

Reaction Mechanisms.
Intergranular Corrosion
Stress Corrosion
Pitting Corrosion
Fretting Corrosion

July 23

Reaction Mechanisms.
Corrosion Fatigue
Thermogalvanic Corrosion
Corrosion in Fused Salts and Molten Metals.

July 24

Corrosion in Non Electrolytes.

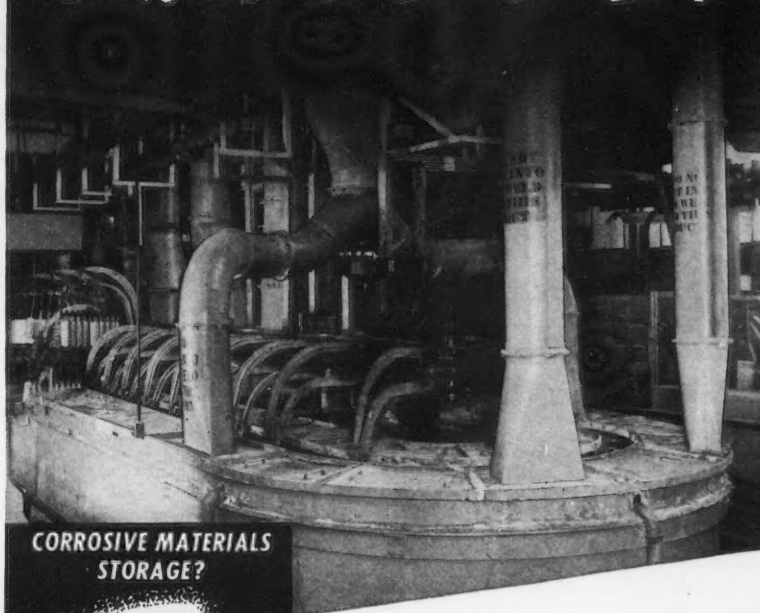
Morning sessions are from 9:00 to noon. The second session each day is held from 7:30 to 10 p. m. There will be no evening meeting Friday. Rooms are available at several inns and hotels in the area if reservations are made in advance. Accommodations are available for a limited number of women to attend each conference also for wives who wish to accompany their husbands.

Applications should be sent to W. George Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, Rhode Island. Since attendance is limited to 100 persons, applications should be forwarded promptly.

Enamel Institute

New uses in all fields of porcelain enameling, including architecture, industry, art and many other categories was scheduled for thorough discussion at the Porcelain Enamel Institute meeting May 6-8, 1953, in Chicago at the Edgewater Beach Hotel.

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Two Semester Paint Technology Course Set at Houston U.

"General Paint Technology—Chemistry 449" is the title of a two-semester course to be offered at the University of Houston in the fall of 1953, according to an announcement by Leslie Martin, chairman of the education committee for the Houston Paint and Varnish Production Club, sponsors of the course in conjunction with the National educational program of the Federated Paint and Varnish Production Clubs.

The course will primarily be a study of the major raw materials and the properties they impart to make coatings effective and also tests on raw materials and on coatings themselves. Several instructors will teach the class on a rotation basis. Members of the Houston Paint and Varnish Club, will be men with many years of experience and training, according to Mr. Martin.

Students will spend three hours a week in the laboratory and three hours in lecture class and anyone interested in learning about paints and coatings may attend. However, to receive four hours credit per semester, the student must have completed courses in quantitative and organic chemistry. Enrollment fee is \$45.

Anyone wishing more information on the course may contact Mr. Martin, Humble Oil & Refining Co., Box 2180, Houston, Tex., or J. Crump, head of the department of chemical engineering, the University of Houston, Houston.

Corrosion Correspondent

William B. Brooks, Electrochemical Engineering Dept., Dow Chemical Company, Freeport, Texas, has accepted the post of Correspondent on the staff of Corrosion magazine representing the chemical processing industries.

Inter Society Committee CORROSION MEETINGS CALENDAR

May 10-15—American Water Works Association—General Convention, Grand Rapids, Mich. (Two papers on corrosion control.)

May 11-14—Midyear Meeting of American Petroleum Institute, Session on Corrosion of Refinery Equipment, New York, N. Y. Commodore Hotel.

June 4-6—Protective Coatings Division Meeting, Annual Chemical Institute of Canada, Conference, Windsor, Ont.

June 15-18—American Electroplaters Society, Annual Meeting, Philadelphia. Benjamin Franklin Hotel. (Some papers on corrosion.)

July 20-25—AAAS Gordon Research Conference on Corrosion, New London, N. H.

August—Symposium on Corrosion, Association Committee on Corrosion Research and Prevention of National Research Council of Canada.

Sept. 13-17—The Electrochemical Society, Fall Meeting, Wrightsville Beach, N. C., Ocean Terrace Hotel.

Oklahoma University to Hold Corrosion Course

Oklahoma University has proposed a corrosion short course seminar to be held early next fall. Facilities are available for conferences, eating, sleeping, and entertainment, according to an announcement by John P. Roberts, professor of metallurgy at the university. The seminar would be the first one on corrosion to be held at the university, Professor Roberts stated.

Information on NACE's Corrosion Abstract Card Service may be obtained by writing to Central Office, 1061 M. & M. Bldg., Houston 2, Texas.

South East Region's Program Announced

The technical program for South East Region's 1953 spring meeting to be held May 7 at Hotel Patten, Chattanooga, has been arranged. NACE members and others interested in corrosion are invited to attend.

The technical program to be presented is:

Thirty Years Experience With Paint Coatings by R. L. Wray, Aluminum Company of America.

Some Factors to be Considered in the Application of Certain Austenitic Stainless Steels by F. L. Whitney, Jr., Monsanto Chemical Company, St. Louis.

Problems Involving Domestic Water Supply Lines by Martin Flentje, American Waterworks Service, Inc.

Engineering Materials in the Textile Industry by H. C. Moss, E. I. DuPont de Nemours, & Co., Inc.

Positive Polarity Grounding of DC Supply Equipment in Mining Traction Systems by S. A. Gibson, Tennessee Coal and Iron Company.

Panel Discussion, Ivy M. Parker, Plantation Pipe Line Company, Atlanta, moderator.

Tour through DuPont nylon plant, Chattanooga.

ASME Meetings Set

The American Society of Mechanical Engineers has announced meetings of the Society to be held in 1954:

June 20-24—Semi-annual Meeting, Pittsburgh, Pa.

Sept. 8-21—Joint IIRD-ISA Conference, Philadelphia, Pa.

Sept. 8-10—Fall Meeting, Milwaukee, Wis.

Sept. 26-29—Petroleum Mechanical Engineering Conf., Los Angeles, Cal.

Nov. 28-Dec. 3—Annual Meeting, New York, N. Y.

Nuclear Conference

An international meeting which will explore the chemical engineering aspects of nuclear processes is being planned by the American Institute of Chemical Engineers for June 20-25, 1954. Engineering educational problems in the nuclear field, design of nuclear power reactors, fuel resources, fuel preparation, chemical processing of spent fuel, disposal of radioactive products, use of isotopes, safety, instrumentation and control will be discussed. A conference on the social impact of the atomic age will be held. One of the members of the Institute's committee on nuclear energy is J. D. Lindsay, A & M College of Texas. Dr. Lindsay is a member of NACE.

Gegner Heads TP-4

Paul J. Gegner of Columbia-Southern Chemical Co., Barberton, Ohio, has been named chairman of Technical Practices Committee 5 on Corrosion Problems Involved in Processing and Handling Chemicals. He succeeds H. W. Schmidt, Dow Chemical Co., Midland, Mich. who is now chairman of the overall committee.

NACE's 10th Annual Conference and Exhibition will be held at Kansas City March 15-19, 1954.

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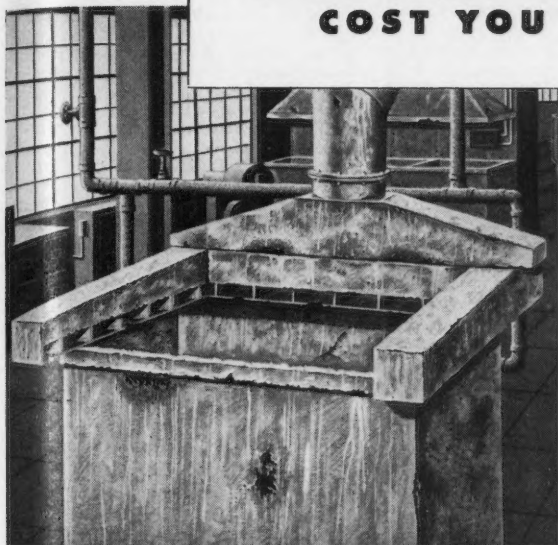
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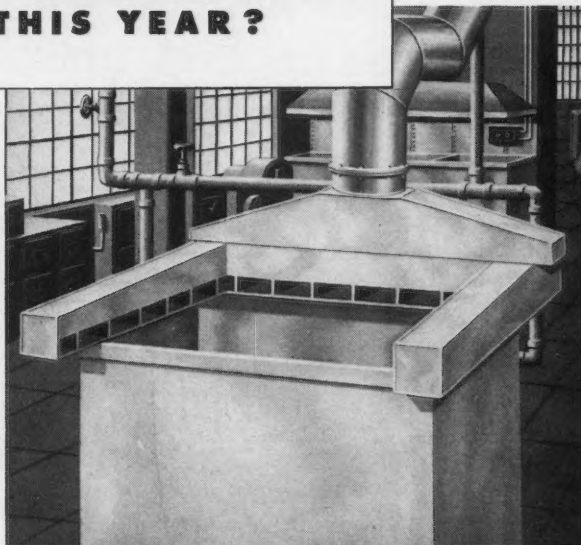
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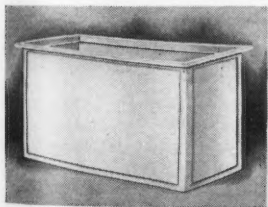


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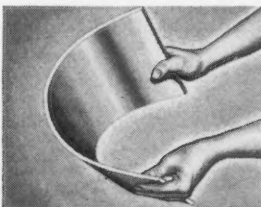
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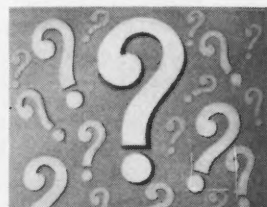
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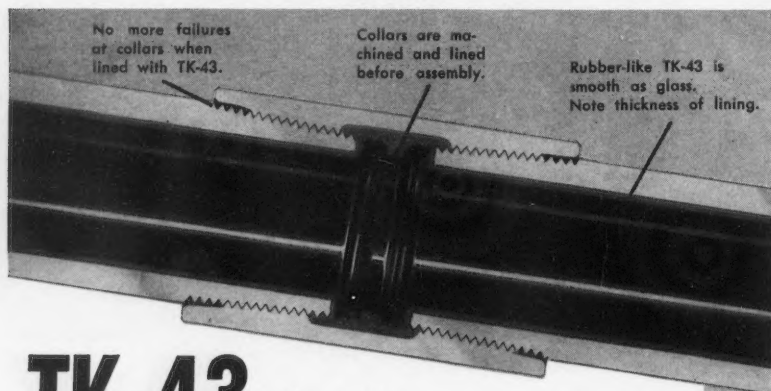
Armour Lists Many Corrosion-Connected Research Investigations

Among the numerous projects carried on by the Armour Research Foundation are the "Development of EP Gear-Lubricant Moisture-Corrosion Test Technique. Object of the project is "to determine the effect of various storage variables on corrosion," and then to devise a means of rating the effectiveness of various lubricants. The Army Ordnance Corps is sponsoring the project to find a way to protect truck and passenger car gears from corrosion during periods of storage.

In another project, flame spraying is

used to apply polyethylene on metallic surfaces. The coating clings to the surface tenaciously and can be applied with a minimum of surface preparation. In titanium research, the problems of developing titanium alloys to fill the gap between aluminum alloys and stainless steel in applications requiring high strength and oxidation resistance at temperatures up to 1000 degrees F are being studied. Working for the U. S. Air Force, the foundation is investigating a 36 percent aluminum titanium-base alloy to develop a lightweight material with excellent oxidation resistance and good strength and hardness at high temperatures.

The Armour Research Foundation does experimental work for private industry which supports it.



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Corrosion Papers Are Given at Los Angeles

Among the numerous papers delivered at the Western Metal Congress held in Los Angeles, Cal. were some of interest to corrosion engineers. These were: "Resistance of Cast Iron Nickel Chromium to Corrosion in Molten Heat Treating Salts," J. H. Jackson, M. H. LaChance, Batelle Memorial Institute, Columbus, Ohio; "Effect of Hydrogen on the Embrittlement of Zirconium and Zirconium-Tin Alloys," W. L. Mudge, Jr., Westinghouse Electric Corp., Pittsburgh, Pa.; and "Austenite Stability and Creep-Rupture Properties of 18-8 Stainless Steels," J. K. Y. Hum, Univ. Cal., Livermore, and N. J. Grant, Massachusetts Institute of Technology, Cambridge, Mass.

Mars G. Fontana, past president of NACE, was co-author of a paper on "Mechanical Properties, Including Fatigue of Titanium Base Alloys RC-130-B and Ti-150-A at Very Low Temperatures." The other authors were: S. M. Bishop and J. W. Spretnak, both of Ohio State University.

British Industries Fair

Among the many things arranged for display at the British Industries Fair, is a roofing felt which takes the place of zinc, copper and lead. According to the makers, Nuralite Sales Ltd., "This non-metallic material is easily weldable, weatherproof and permanent."

Another firm will exhibit chromium-plated aluminum fittings for merchant ships and aircraft. The fittings are processed at high speed. Experiments are being conducted on brassing and steel bronzing of aluminum castings which will result in a lower cost over articles made entirely of brass. The Fair is scheduled for April 27 to May 8, in England.

Metal Stitching Speeds Aircraft Construction

One of the technical papers prepared for presentation at the 21st annual meeting in Detroit of the American Society of Tool Engineers was one on Metal Stitching. The author, Arthur G. Denne, manager, round stitching wire department, Acme Steel Products Div., Acme Steel Co., Chicago, Ill., says tests have shown stitched parts taken from aircraft used in both arctic and tropical regions successfully resisted both corrosion and vibration. Metal stitching also speeds up production in some cases, he said. One sweeper manufacturer jumped production from 40 to 550 sweepers per day.

Another paper maintained that metallurgists are now key men in industry because advancements in the field have been so rapid that engineers engaged in other branches of science cannot keep pace.

Requests for additional copies of Corrosion should be addressed to Central Office, NACE, 1061 M & M Bldg., Houston 2, Texas. Single copies are sold to members at 50c each and to non-members at \$1 each. A list of exhausted issues is published frequently during the year in Corrosion.

SOCIETY MEETINGS

(Other than NACE)

May

- 6-8—Porcelain Enamel Institute, Mid-year Divisional Meeting, Chicago, Ill.
 7-8—Society of Naval Architects & Marine Engineers, Boston, Mass.
 14—Instrument Society of America, Metropolitan Section, co-sponsor with Manhattan College on Conference on Instrumentation in Water, Sewage and Industrial Waste Treatment, New York, N. Y.
 18-19—Association of Iron & Steel Engineers, Buffalo, N. Y.
 24-28—American Society of Mechanical Engineers, Oil and Gas Power Div., Conference, Milwaukee, Wis.
 27-28—American Iron & Steel Institute, General Meeting, New York, N. Y.
 27-29—American Society for Quality Control, 7th Annual Convention, Philadelphia, Pa.

June

- 7-12—Society of Automotive Engineers, Summer Meeting, Atlantic City, N. J.
 15-17—American Society of Agricultural Engineers, Annual Meeting, Pittsburgh, Pa.
 15-19—American Society of Civil Engineers, Miami Beach, Fla.
 16-17—American Welding Society, Spring National Meeting, Houston, Tex.
 18-20—The American Society of Mechanical Engineers, Applied Mechanics Conf., (Eastern), Minneapolis, Minn.
 23-26—American Society for Testing Materials, Annual Meeting, Atlantic City, N. J.
 23-27—American Society for Engineering Education, Annual Meeting, Hanover, N. H.
 28-July 1—The American Society of Refrigerating Engineers, 40th Spring Meeting, Lake Placid, N. Y.
 28-July 2—The American Society of Mechanical Engineers, Semi-Annual Meeting, Los Angeles, Calif.
 29-July 3—American Institute of Electrical Engineers, Summer General Meeting, Atlantic City, N. J.

July

- 16-19—American Welding Society & Exposition, Houston, Tex.
 21-27—XXIV Congrès International de Chimie Industrielle, Paris, France.
 20-25—American Institute of Chemical Engineers, Aspects of Nuclear Processes, Ann Arbor, Mich.

August

- 9-12—American Transit Association, Annual Convention, Los Angeles, Calif.
 17-19—Society of Automotive Engineers, International West Coast Meeting, Vancouver, British Columbia.
 18-21—American Institute of Electrical Engineers, Vancouver, British Columbia.

September

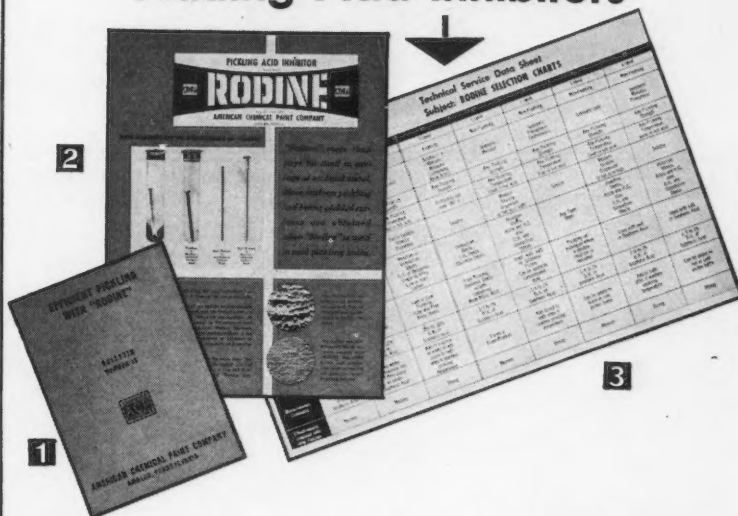
- 13-16—American Institute of Chemical Engineers, California Meeting, San Francisco, Calif.
 14-17—Society of Automotive Engineers, National Tractor Meeting and Production Forum, Milwaukee, Wis.
 21-25—The American Society of Mechanical Engineers, Joint IIRD-ISA Conference.
 28-Oct. 1—Association of Iron and Steel Engineers, Annual Convention.
 13-17—Electrochemical Society, Fall Meeting, Wrightsville Beach, N. C.

(Continued on Page 18)

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SOCIETY MEETINGS

(Continued from Page 17)

16-18—Porcelain Enamel Institute, Annual Shop Practice Forum, Columbus, Ohio.

30-Oct. 2—Porcelain Enamel Institute, 22nd Annual Meeting, White Sulphur Springs, W. V.

October

19-23—American Welding Society, 33rd Annual Meeting, Cleveland, Ohio.

19-23—American Society of Civil Engineers, Annual Convention, New York, N. Y.

19-23—American Society of Metals, National Metal Congress and Exposition, Cleveland, Ohio.

29-30—The American Society of Mechanical Engineers, Fuels—AIME Coal Conference.

30-31—Society of Advancement of Management, Annual Fall Conference, New York, N. Y.

November

2-4—Society of Automotive Engineers, National Transportation Meeting, Chicago, Ill.

3-4—Society of Automotive Engineers, National Diesel Engine Meeting, Chicago, Ill.

5-6—Society of Automotive Engineers, National Fuels and Lubricants Meeting, Chicago, Ill.

12-13—The Society of Naval Architects and Marine Engineers, 61st Annual Meeting, New York, N. Y.

29-Dec. 4—The American Society of Mechanical Engineers, Annual Meeting, New York, N. Y.

December

6-9—The American Society of Refrigerating Engineers, 49th Annual Meeting, Washington, D. C.

7-9—American Society of Agricultural Engineers, Winter Meeting, Chicago, Ill.

13-16—American Institute of Chemical Engineers, Annual Meeting, St. Louis, Mo.

26-31—American Association for the Advancement of Science, Boston, Mass.

H. A. Forsberg Receives Lorenz Gold Medal

The top award of the Steel Founders' Society, the Lorenz Memorial Gold Medal was given to Henning A. Forsberg, vice president, Continental Foundry & Machine Co., East Chicago, Ind. John A. Rassenfoss, assistant research director, American Steel Foundries, East Chicago, Ind., received the annual Steel Foundry Facts award for excellence of material published in the society's technical publications. The awards were given at the society's annual convention held in Chicago.

Dechema Volume Ready

Lectures by 24 important scientists and engineers coming from nine different European countries and the United States form the text of Volume 21 of the series of Dechema Monographs published in German. The lectures are said to be "very comprehensive and, in part, elaborated." The book consists of 464 pages with 186 illustrations and numerous tables.

Among the lectures are four on "materials used in the construction of chemical engineering equipment," and one on "the realization of extreme conditions in industrial chemical engineering." The volume also includes an author's index as well as a general index in German, French and English. It is published by Verlag Chemie G.m.b.H., Weinheim, 1952. The book, with hard backs, costs DM 37.50.

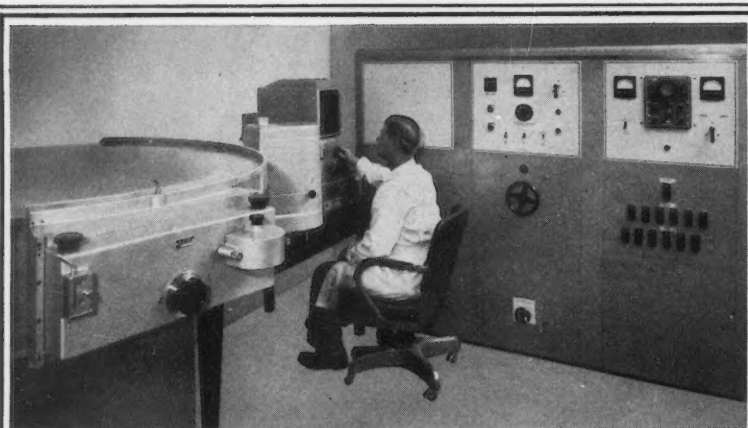
A. L. Stegner Presides

A. L. Stegner, Tennessee Gas Transmission Co., presided at the Corrosion Symposium held at the 25th Annual Conference, and Exhibition of the Petroleum Industries Electrical Association held in Houston, at the Shamrock Hotel April 7-9, 1953. Mr. Stegner is a member of the Houston Section, NACE.

300 Committees Meet

The American Society for Testing Materials held more than 300 meetings when the organization held its "Committee Week" in Detroit March 2-6. The society has as its purpose establishment of specifications for industry and research work.

In 1952, for every page of advertising published in CORROSION two pages of editorial matter were published.



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German Corrosion Terms Are Translated

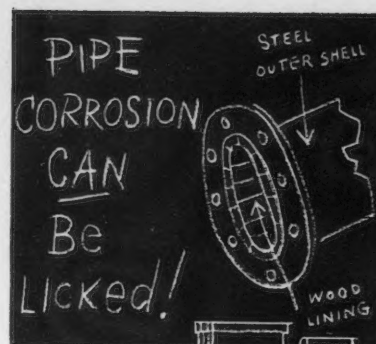
Following is an English translation of German terms used in German corrosion technology. It is from a paper by Gerhardt Schikorr of the magazine, *Werkstoffe u. Korrosion*, 3 110-115 (1950). The published paper describes German Specification DIN 50,9000. Where the words have no exact English counterpart, a brief description of their meaning is given. Dr. Hugh P. Godard, Aluminium Laboratories, Ltd., Kingston, Ont., Canada, compiled the terms from a translation of the paper into English by Dr. J. Mloszewska of Aluminium Laboratories staff.

GERMAN

ENGLISH

Anlaufen	Tarnishing
Beizblasen	Pickling blisters
Beizen	Etching, Pickling
Beizsprödigkeit	Pickling brittleness
Belüftungselement	Oxygen concentration cell
Berührungskorrosion	Contact corrosion
Blüten	Formation of red iron oxides in the process of friction oxidation
Bodenkorrosionsversuch	Soil corrosion test
Bügelprobe	Bow sample (stress corrosion testing)
Dampfversuch	Steam test
Druckgefäßversuch	Corrosion test in liquids and steam at elevated temperature and under pressure.
Durchlöcherung	Perforation
Ebenmässiger Angriff	Uniform attack
Entzinkung	Dezincification
Fernschutzwirkung	Cathodic protection of a metal by contact at a distance with a less noble metal
Fremdströme	Stray currents
Flugrost	Easily removable primary rust that forms a thin coating on iron and steel in the atmosphere
Fremdrost	Deposits of rust that stem from iron particles settled on iron and steel (particularly on stainless steel)
Gabelprobe	Fork sample (stress corrosion testing)
Graphitierung	Graphitization
Grünspan	Verdigris
Hebelprobe	Elastically, also occasionally plastically deformed sample, usually of strip or slab shape for stress corrosion testing under constant load.
Hemmstoff	Inhibitor
Irrströme	Stray currents
Kochversuch	Boiling test
Kontaktkorrosion	Galvanic corrosion
Korngrenzekorrosion	Intergranular corrosion
Korngrenzriss	Grain boundary crack
Korrosionsermüdung	Corrosion fatigue
Künstliches Meerwasser	Artificial seawater
Kurzzeitprüfung	Accelerated corrosion testing (hours to weeks)
Laboratoriumversuch	Laboratory testing
Langzeitprüfung	Corrosion testing simulating service conditions
Lochfrass	Pitting
Modelllösung	Synthetic corrosion test medium
Narbe	Local corrosion flat point
Naturversuch	Field test
Nichtrostender Stahl	Stainless steel
Oxydische Kochsalzlösung	Salt-peroxide solution (3% NaCl 0.1% H ₂ O ₂)
Probe	Sample
Prüfstück	Test piece
Prüfung	Test, testing
Reiboxydation	Friction oxidation (fretting corrosion)
Rost	Rust

(Continued on Page 20)

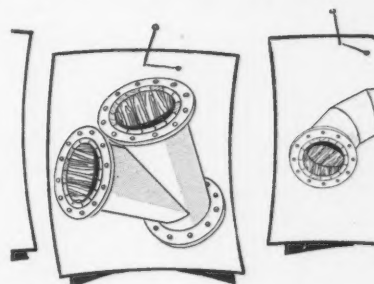


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easy as **MPC!**

MPC Wood-Lined Steel Pipe is the efficient and economical answer wherever corrosion, abrasion, frictional resistance or sliming is a problem.

Ideal for corrosive liquids, gases and fumes including aggressive waters, industrial waste liquors, pulps, slurries, acid, alkali and salt solutions.

For service up to 180° F. and 250 p.s.i. Higher pressure ratings for special service requirements. All pipe flanged and available in 10' and 20' standard lengths or "tailor-made" to your specifications. Easy to cut and re-flange. All flanges have standard ASME bolt circle.



Woodlined fittings are available in standard and special designs for all diameters. For catalog and additional information write Dept. C.



MICHIGAN PIPE COMPANY

Boy City • Michigan

Manufacturers of Wood-Stave, Saran Rubber-Lined, Stainless Steel and Monel Piping. Represented nationally by Saran Lined Pipe Co. Detroit, (Ferndale) Michigan.

German Corrosion Terms Are Translated

(Continued from Page 19)

Rührversuch
Schichtkorrosion
Schlaufenprobe
Schnellkorrosionsprüfung

Schutzschicht
Schwefelpocken
Spaltkorrosion
Spannungskorrosion
Sparbeizzusatz
Sprühversuch
Standversuch

Schwitzwasserkorrosion

Unterschiedliche Belüftung
Vagabundierende Ströme
Wasserdampfspaltung

Wasserstoffkrankheit
Wechseltauchversuch
Weisser Rost
Zunder

Zundersausblühungen

Immersion test with stirring
Layer corrosion (Lamellar corrosion)
Loop sample (stress corrosion test)
Rapid accelerated corrosion testing (a few hours at most).

Protective coating
Sulfur spots
Crevice corrosion
Stress corrosion
Pickling inhibitor
Spray test
Simple immersion test in absence of stirring

Corrosion due to water that has condensed on the metal surface

Differential aeration

Stray currents

A reaction between steel and water vapor in steam boilers with the evolution of hydrogen

Hydrogen embrittlement of copper

Alternate immersion test

White rust (zinc)

Solid corrosion products forming on the surface of metals at high temperatures in the presence of oxidizing gases.

Local heavy growth of forge scale due to destruction of protective action of oxide coatings: often due to local overheating.

Electrochemical Society Sets Corrosion Session

Sessions on corrosion, electrodeposition and batteries will be held at a September 13-16, 1953, meeting of The Electrochemical Society, Inc., at Ocean Terrace Hotel, Wrightsville Beach, N. C. Other divisions may schedule sessions later.

The LaSalle Hotel, Chicago, will be the site for sessions by the society May 2-6, 1954. Sessions will be announced later.

Paper on Plastic Pipe

Southern Gas Association's May 11-13 meeting at New Orleans will include one paper of corrosion interest, "Use of Plastic Pipe in Distribution Systems" by L. R. Pickup of Southern California Gas Company will be given on the afternoon of May 11.

Headquarters hotel is the Jung.

Wahlquist to Talk

"The Place for Zinc in Cathodic Protection," by H. W. Wahlquist was one of the technical papers scheduled for delivery at the 35th Annual Meeting of the American Zinc Institute, meeting in St. Louis, April 27-28. Mr. Wahlquist is a member of the National Association of Corrosion Engineers.

Electromotive Forces Probed at Rensselaer

Fundamental investigations of electromotive forces for metals immersed in liquids other than water are sponsored by Air Research and Development Command at Rensselaer Polytechnic Institute, Troy, N. Y. Dr. George J. Janz of the chemistry faculty is directing the project.

Joint Meeting Is Held At Toronto, Canada

Meeting jointly for the first time, the American Institute of Chemical Engineers and the Chemical Engineering Division of the Chemical Institute of Canada convened April 26-29 in Toronto, Ontario. Subjects ranging from radio chemical processing to the use of scale models in chemical plant design, eighteen technical papers and other features were scheduled.

NBS Publishes Book Summarizing Work

The National Bureau of Standards has published a summary of scientific and engineering investigations conducted by NBS during the fiscal year 1952. The booklet contains accounts of current activities as well as more detailed descriptions of representative projects. The booklet, Annual Report 1952, National Bureau of Standards Miscellaneous Publication 207, costs 30 cents and may be ordered from Government Printing Office, Washington 25, D. C.

YOU Can PAINT OVER RUSTY STEEL!
without Expensive Surface Preparation

Even in Corrosive, Humid or Dirty Atmospheres, **RUSTBOND PRIMER** sticks to rusty and corroded steel.

Rustbond Primer contains a new vehicle which wets and acts on rust—without forming water or oxygen. Bond to steel increases with time. Part of the rust disappears, too.

Rustbond Primer coats sharp edges as heavily as it does flat surfaces—often more heavily. Failure of finish paint films on the sharp edges of structural steel is reduced from the usual 72% to practically zero.

Rustbond Primer itself has good corrosion resistance. Stops most undercoating corrosion on steel when steel is exposed by physical damage or skips in topcoat.

Rustbond Primer is easy to apply. Just stir and brush on like paint. Costs no more than a good red lead primer. Only one coat is required.



- Take off loose rust by wirebrushing
- Coat with **RUSTBOND PRIMER**
- Put on two coats of your corrosion resisting finish—the one which is otherwise satisfactory for your conditions. No intermediate coat necessary.

Vinyls won't peel from wirebrushed rusty surfaces when used with Rustbond Primer. With other primers, the steel must be sandblasted.

Bulletin 150 describes some rigid tests made of Rustbond Primer by the country's largest chemical plants.



CARBOLINE COMPANY
333 Thornton Avenue • St. Louis 19, Mo.

Essay Contest Opened

The Electrochemical Society is sponsoring an essay contest on "Contributions of Electrochemistry in Science." First Prize is \$100, second prize is \$50. Both winners are given a one-year membership in the society. The contest is open to undergraduate and graduate students. Essays should reach the Corrosion Division Essay Committee, The Electrochemical Society, 235 West 102nd St., New York 25, N. Y. before July 1, 1953.

Standard Test Sought For Alkaline Resistance Of Porcelain Enamels

A new sub-committee of the Quality Development Committee of the Porcelain Enamel Institute has been named to prepare a standard test method for determining the alkali resistance of porcelain enamels. The need for such a test has developed because of the increasing use of high alkali detergents.

John T. Roberts of the Crane Company is chairman of the 8-man committee which includes representatives of major industries using porcelain enamel.

Tate Gets Gregory Award

Joseph B. Tate of the Witt Cornice Co., Cincinnati, Ohio., and Frederick C. Brightly, Jr., of the Brightly Galvanized Products Co., Cicero, Ill. were presented the Thomas M. Gregory Memorial Award for the years 1951 and 1952 respectively at the American Hot Dip Galvanizers Association 1953 Annual Meeting in Cincinnati.

More Engineers Needed

The need for more engineers to serve all phases of industrial production "from research to the finished product," was the repeated theme at the American Society of Tool Engineers 21st annual national meeting held March 18-20. Elected to head the Society was Roger F. Wainde, Muskegon, Mich.

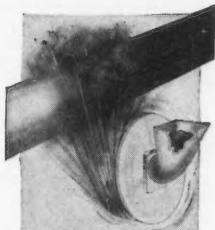
Milwaukee Engineering School Is Honored

As part of a 50th anniversary celebration honoring the Milwaukee School of Engineering, many prominent industrial and business figures were scheduled to meet in Milwaukee, May 4. An estimated 50,000 persons have been trained by the school. Charles P. Steinmetz, electrical genius, was once on the school's advisory board.

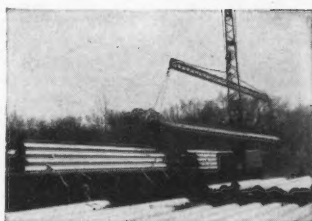
Manuscripts on subjects dealing with Corrosion from any source are considered for publication in Corrosion magazine. The association, in general, prefers not to publish material which has appeared in other readily available periodicals, or which consists solely of an advertising sales message. Copies of the NACE "Guide for the Preparation and Presentation of Papers" are available on request.

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* **standard pipeprotection inc.** designed and built the first plant to include all the machines and methods and procedures necessary to set the highest standards, and to produce the finest coated and wrapped pipe.



FIRST plant to use steel grit cleaning exclusively, on every piece of pipe, regardless of size . . . no other cleaning method is used in this plant. Steel grit cleaned surfaces are made up of many tiny facets, inclined toward each other at various angles, which help to key or bond the coatings to the steel.



FIRST plant to equip all cranes with spreader bars, while your pipe is being unloaded and loaded . . . to prevent pick-up cables putting the pipe under longitudinal strain, eliminating damage, dogleg bending or damage to pipe ends.



FIRST plant to provide warm air conditioned storage areas for wrappings — felts, glass, and paper — in order to prevent their absorbing moisture from the atmosphere. If wrappings with a high moisture content are applied to the pipe, the hot enamels vaporize the moisture, thereby causing excessive holidays.

Standard procedures provide application to customers' specifications, in accordance with your regular procedures . . . any of the coating manufacturers' materials . . . and in any combination of applications of these coatings, felts, wrappers, glass and kraft paper.



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NEW PRODUCTS — Materials — Service — Literature

Fastenings manufactured by H. M. Harper Co., 8251 Lehigh Ave., Morton Grove, Ill. are described and illustrated in a folder now available. Sizes are listed.

Pfaudler Company, Rochester, N. Y. held a three-day seminar on corrosion resistant process equipment at the opening April 13 of a newly completed research building. E. A. Sanford, Pfaudler director of research was chairman of the opening session.

Rust-Anode, trade name for a coating said by the manufacturer to consist of a solution of pure zinc and an unidentified suspension fluid, can be applied by brush, dip or spray. Literature supplied by the company says the zinc remains in metallic contact with base metal, assuring cathodic protection through the preferential corrosion of the zinc. Loose scale and rust must be removed and surfaces must be free of grease and moisture before application. Temperature stability to 400 degrees F is claimed, and shock tests at temperatures from -40 to +400 degrees F show no signs of crazing or loss of adhesion or protective ability. The paint may be used as a base for decorative paints, except that when bitumens or cellulose are to be applied a sealer is necessary. A British development, the material is being sold in the United States by Cold Galvanizing Corp. of America, Inc., 9 West 57th St., New York 19, N. Y.

Corrosion-Resistant sanitary and industrial centrifugal pumps are offered in a complete line by Tri-Clover Machine Co., Kenosha, Wis. They are available in sizes and capacities up to 1250 gallons a minute and up to 250 feet of head at zero gallons per minute. Industrial pumps are designed to pump latex, water, brine, light oil, chemicals, paints, brewery products. Catalog 250 describes the pumps.

Bart Manufacturing Corp., Belleville, N. J., has opened a 12,000 square foot addition for precision electroplating equipment being produced for Atomic Energy Commission projects.

A New Rubber Linings Bulletin just issued by the Protective Coatings Div. of Metalweld, Inc., Scotts Lane and Abbottsford Ave., Philadelphia 29, Pa., contains detailed information on the chemical, abrasion and temperature resistance of rubber linings, together with tables on organic and inorganic acids and miscellaneous materials. This eight page illustrated folder is available on request.

Export Packaging, an illustrated manual on wood-box export packaging is offered by National Wood Box Association, Barr Bldg., Washington 6, D. C. Recommended methods of fabricating and strapping wooden containers are given. Protecting the contents from corrosion by contact preservatives, water proofing barriers, strippable coatings and dehydration are described.

American Metaseal Manufacturing Corp., 30 East 60th Street, New York 22, N. Y. is offering equipment which can be used for vacuum impregnating porous castings. The company also supplies an impregnating material which is applied without a solvent. The resulting impregnation is without the porosity characteristics of other impregnants, the company says.

Middle West Coating and Supply, 207-A Daniel Bldg., Tulsa, Okla. is offering a new catalog describing Vitrabestos, a new reinforced asbestos pipe line felt manufactured by Nicolet Industries, Inc., New York. The new material is reinforced with textile fibers running parallel at half-inch intervals. This strengthening material is designed to reduce breaks and improve wrapping time. Properties of the Nicolet 15 and 8 lb. felts are given and tables are provided for quantities per mile for each weight.

Prufcoat Laboratories, 50 East 42nd St., New York 17, N. Y. says its new CP-Vinyl system combines the highly desirable properties of a heavy duty drying oil primer with the well-known chemical resistance of vinyl coatings. The company claims its system provides a substantially greater "edge build" than can be secured with other systems. While a plane surface vinyl thickness of 5 to 6 mils frequently is required to obtain desired edge thickness with some vinyl systems, Prufcoat claims its Primer P-50 lowers the optimum thickness for plane areas to 4 mils. The primer gives 2 mils dry film thickness on flat areas in one coat. Substantially improved adhesion to bases and between coats also is claimed. Undercutting and creepage are reduced by the inhibitive effect of pigments included in the primer, tests in salt spray showing effective protection at score marks on panels at 672 hours.

Pop Rivets, made in Monel and aluminum, are now being manufactured in the United States by J. C. Rhodes and Co., New Bedford, Mass. Long used in England, the rivet can be used to fasten most common metals and alloys from one side. The rivet is expanded on the side away from the operator by a headed mandrel, which is drawn back into the shank of the hollow rivet while the head is held firmly against the metal. After expanding the rivet tightly, the mandrel head breaks off and the shank of the mandrel is withdrawn and discarded.

The Flotation Company, Inc., Elizabeth, N. J. has been formed as an applicator of Aqua-Seal protective coatings to the submersible areas of water-sealed gas holders by the flotation process. E. R. English will be vice-president and general manager of the new company. The flotation process was described in Corrosion's January, 1953 issue.

Steellast, a coating consisting of stainless steel suspended in a vinyl vehicle is now available in seven colors. The

coating is said by the manufacturers, Steelcote Mfg. Co., St. Louis, Mo. to resist wet heat up to 180 degrees F. and constant dry heat up to 300 degrees.

A Foaming Flotation agent, available in both edible and commercial grades is being made as a dairy by-product by Western Condensing Company, Appleton, Wis. A natural product, it is non-toxic. Inquiries concerning possible uses are welcomed.

Precision Machine Co., 8 Walnut St., Somerville 43, Mass. is manufacturing a chemical solution feed pump in two models. The Model S pump is a positive displacement, diaphragm type pump with a shaded pole electric motor and a reduction gear train contained in an acid-alkali resistant enameled case and immersed in oil. The diaphragm is reciprocated by an eccentric cam. Parts coming into contact with the pumped solution are of plastic or synthetic rubber and plastic tubing connects the unit to solution source and main products or water line. The pump head assembly consists of 7 major parts and can be assembled in a few minutes. The unit will pump against 150 psi pressure. A duplex pump with two heads of essentially the same construction will pump from 5 to 60 gallons per hour. Each head may be adjusted independently and can be made while the unit is running. The pump was designed principally for chlorination of water and industrial wastes.

Babcock & Wilcox Company has established an Atomic Power Division to be headed by C. H. Gay, formerly head of the manufacturing department of the company's boiler division.

Alloy Rods Company, York, Pa. has published Bulletin AR53-16, a 20-page catalog in color on its line of stainless steel electrodes. Individual descriptions of the 23 regular analyses and special analyses of the electrodes, weld metal properties, welding procedures, and color charts, current ranges and AISI type numbers are given.

Mylar Polyester Films, a product of E. I. duPont de Nemours & Co. are described in Bulletin No. 1-2-53. The material, now being produced in limited quantities for market development purposes, is a film made from polyethylene terephthalate, the polymer formed by the condensation reaction between ethylene glycol and terephthalic acid. It remains flexible over a temperature range of -60 to 150 degrees C, and is impermeable to a number of organic and inorganic gases, the company says. The bulletin gives tables of data on the material and makes extensive graphic comparisons with other polymers.

Universal Metal Rose Company, 2133 South Kedzie Ave., Chicago 23, Ill. has issued a Technical Data Book U-111 describing its interlocked and leakproof flexible hose made from bronze, carbon and stainless steel. Sizes, capacities and other characteristics are detailed.

(Continued on Page 24)

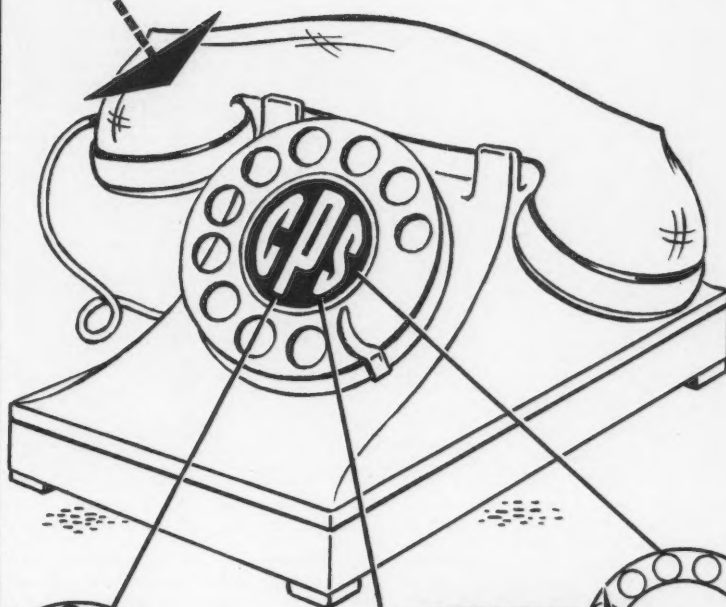
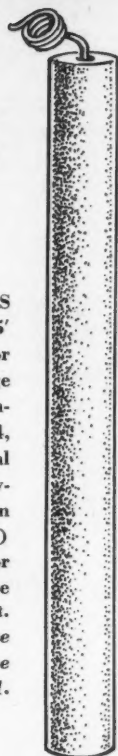


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CPS GRAPHITE ANODES

—3"x60" with 3' or 5'
lead wire, Regular or
Specially Treated. Large
reserve stocks of unfin-
ished cylinders and of #4,
#6 and #8 direct-burial
cable (including heavy-
wall Polyvinyl insulation
for use in oil-soaked soil)
are on hand for
immediate lead-wire
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OTHER FIRST LINE MATERIALS INCLUDE:

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Detectron Pipe Locators
Wahlquist Pipe Locators
CPS Graphite Anode Backfills
Homco and Barada and Page Backfills
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Everything in the cathodic protection field . . .
from an insulating washer to a turnkey contract installation.

NEW PRODUCTS

(Continued from Page 22)

Insul-Mastic Corp., 1141 Oliver Bldg., Pittsburgh 22, Pa. has compiled a 4-page folder containing charts which indicate the degree of protection from condensation afforded by Insul-Mastic Type D. The sprayable coating is designed for use where a moderate amount of insulation is needed in conjunction with a corrosion preventive, such as on heated storage tanks or cold pipes or vessels.

Pliogard, a new chemical and corrosion resistant rubber base coating, formulated from a heat-stable thermoplastic resin obtained by the copolymerization of styrene and butadiene, is recommended for use where a durable and lasting finish for floors, walls and structural steel, tanks, ducts and process equipment is required. Saran Protective Coatings Co., 2415 Burdette Ave., Ferndale 20, Mich., an affiliate of Saran Lined Pipe Co., says the films produced are tough and exceptionally inert to most chemicals. High adhesion to all clean, dry surfaces is claimed for the coatings which can be applied by spray, brush or dipping. The coating is non-oxidizing and non-saponifiable and has excellent durability in highly alkaline environments. Additional data can be obtained on request.

Silica Content of boiler water used to produce steam for high pressure turbines should be kept at not over 5 ppm, Martin E. Gilwood director of research for the Permutit Co., New York told the American Power Conference at Chicago March 27. His paper "Mixed Bed vs. Two-Step Demineralization of High Pressure Boiler Feedwater" described how ion exchange methods can be used to keep silica content low. High silica content results in deposition of silica on turbine blades in the low pressure stages of turbines.

Bakelite Polyethylene, a 24-page booklet published by Bakelite Co., a Division of Union Carbide and Carbon Corp., 260 Madison Ave., New York City, describes and illustrates the many uses to which polyethylene is being put now. Tables show relatively high impermeability of the material to oxygen and carbon dioxide and its comparatively low vapor transmission rate. Other data on resin compatibility, chemical resistance, and manufacturing methods are given. Copies are available on request.

Eagle Chemical Co., Joliet, Ill. has completed a new manufacturing plant at Mobile, Ala. to produce the firm's new clay desiccant, silica gel and coatings trade named Spray-Strip, MZP-Kote, Trans-Kote and Soft-Kote.

Scotch Electrical Tape No. 5, a 3-mil transparent film with tensile strength of 35 lb. per inch in width, stretch of 150 percent before breaking, insulation resistance of 100,000 megohms, dielectric strength of 5,500 volts and an electrolytic corrosion factor of 1.0 is being manufactured by Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul 6, Minn. It is made from Mylar new DuPont film.

Mission Manufacturing Company, Houston, is producing a phenol-formaldehyde resin or furfural alcohol resin solid plastic pump to handle acids, bases, salts and other chemicals. The pump is designed especially for mechanical seals and the fluid end parts are of solid plastic. It is made in 3-inch suction, 2-inch discharge size only, with a capacity of 300 gpm and heads up to 110 feet. Operating temperatures may be up to 265 degrees F. Bulletins CP-P 11-51A and CP-PH 1-52 describe these pumps.

Kenneth Tator Associates, Coraopolis, Pa., has established a custom corrosion testing service for industrial environments. The test stations are located in plants of large industrial companies where exposures are available to fumes, mineral acids, ammonia, organic solvents, entrained corrosive chemicals, high humidity, radiant heat, salt, mildew and others.

PERSONALS

R. B. Waters has been appointed sales engineer in Ohio for Thompson & Co., Oakmont, Pa. In his new capacity, with headquarters in Cleveland, Ohio, he will sell and service the Thompson line of industrial coatings, including electrical insulation varnishes and the Vinsynite series of metal pretreatments.

Edmund S. Ruffin, Jr. was recently appointed departmental vice president of Koppers Company, Inc. Mr. Ruffin has been secretary of the company since 1938 and chief counsel and manager of the company's law department since 1942. He joined Koppers in 1929 as a member of the company's law department. While attending the University of Virginia law school, Mr. Ruffin was editor of the Virginia Law Review.

David D. Hicks has been appointed manager of personnel administration and training for Koppers Company, Inc.

Edward J. Martin will assume duties of training director in the Industrial Relations Dept., for Koppers Company, Inc. He was formerly a staff training assistant.

Dr. Ray E. Heiks has been named by Director Clyde Williams to supervise Battelle Institute's solid-state chemistry laboratories. In his new position, Dr. Heiks will head a research group studying the chemical aspects of semiconductor materials. He has conducted studies on selenium, anti-fouling compositions and wood preservatives during his 10 years as a member of the Battelle staff. He has served on the special committee of the American Wood Preservers Association on fundamental research on all preservatives and is a member of the Forest Products Research Society, and the Seahorse Institute.

E. O. Owens and **Don L. Long** have been appointed as sales and service engineers for the T. D. Williamson, Inc. Mr. Owens, who has been employed in corrosion engineering and cathodic protection capacities with various organizations has been assigned the states of Oklahoma, Arkansas, Missouri, Kansas and the eastern half of Nebraska. Mr. Long, with experience in the field of

design and construction engineering has a territory covering several other states.

S. C. Johnson has been elected as a member of the board of directors of the Dearborn Chemical Co. Mr. Johnson is a vice president of the company and heads the railroad department, Eastern division. Mr. Johnson has been with the Dearborn Chemical Co. for 23 years.

J. F. Wilkes was recently appointed Director of Research and Product Development, in which capacity he will maintain responsibility for the operation and administration of the company's laboratory. Mr. Wilkes joined the company in 1939 as chemical engineer.

Harry W. Moore, Tulsa, Okla., has been named Southwestern Representative of the St. Louis Metallizing Company. Mr. Moore has had long experience in contract metallizing, hard surfacing, and coatings application.

Synthane Corp. of Oaks, Pa., manufacturer and fabricator of laminated plastics for industry, has announced the appointment of **Oliver L. Smith** to their New York District sales staff. Mr. Smith will service industrial accounts in Eastern New York state and part of Manhattan.

Oliver L. Smith has been added to the New York district sales staff of Synthane Corp. of Oaks, Pa., manufacturer of laminated plastics.

Clifford Armstrong has been appointed exclusive agent for Carboline Company in Michigan, Ohio and Ontario. He formerly was materials engineer with Wyandotte Chemicals Corp.

Edward H. Platz, Jr., manager of alloy sales for Lebanon Steel Foundry, Lebanon, Pa. has returned to his post after duty with the National Production Authority as nickel specialist.

Robert W. Pelz has been appointed director of research of the Ferro Corp., Cleveland.

H. D. Hughes has been appointed general sales manager and **E. E. Fogle**, sales manager of the Industrial Chemicals Division, Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp. Mr. Fogle has just returned from seven months' service with the Office of Price Stabilization as director of the Rubber, Chemicals, Drugs and Fuel Division.

Harry E. Beane has been appointed Vice President of Sales of the Bristol Co., Waterbury, Conn., manufacturers of automatic controlling, recording, telemetering, and aircraft instruments and socket screw products. He will continue to make his headquarters at the general offices of the company in Waterbury, Conn.

Robert H. Gardner, 58, general sales manager for A. M. Byers Co., died in a Pittsburgh, Pa., hospital, March 9. Mr. Gardner joined A. M. Byers Co. in 1933 and served as division manager of the firm's Washington, D. C. office prior to his appointment as general sales manager in 1945.

(Continued on Page 25)

PERSONALS

(Continued from Page 24)

Vincent R. Cioffi was appointed general sales manager of Belco Industrial Equipment Division, Inc., with headquarters in the Belco Bldg., 100 Pennsylvania Ave., Paterson, N. J.

Ben C. Montgomery, Owens-Corning Fiberglas Co., is the firm's new sales representative in Houston. Mr. Montgomery came from Toledo, Ohio. He is promoting sales of pipe wrapping materials. Branch office address is 1114 Texas Avenue Bldg., Houston.

Robert L. Werkheiser has been named Chicago representative for Monsanto Chemical Company's industrial resins sales department. Mr. Werkheiser has been in the division's research department since 1949. Before joining Monsanto, he was a research chemist with Interlake Chemical Co. of Chicago, Ill. He will service Monsanto's industrial resins customers in Minnesota and Wisconsin, as well as those in Chicago, Ill.

Louis L. Potomac has been elected president of the Reflin Company, Los Angeles producer of glass fiber reinforced thermosetting plastic pipe.

John S. Hackett has been put in charge of the newly developed transportation division of The Debevoise Company, 74-84 20th St., Brooklyn 32, N. Y. **William Barnack, Jr.**, a Pratt Institute graduate, has been named chief chemist for the company.

Durando Miller, Jr. has been promoted to assistant technical manager by The Permutit Company, 330 West 42nd St., New York 36, N. Y.

George W. Naylor has been named assistant vice president and assistant sales manager for Tar Products Division of Koppers Company, Inc. **Donald MacArthur**, formerly assistant manager of the Central Staff Sales Department of Koppers has been made manager of the firm's Washington office.

Harrol J. Dawe has been promoted to the post of technical Director of Acheson Colloids Company, Division of Acheson Industries, Inc., Port Huron, Mich. **Alden Crankshaw** has been made sales manager for Acheson Colloids and **John W. Shier** production manager.

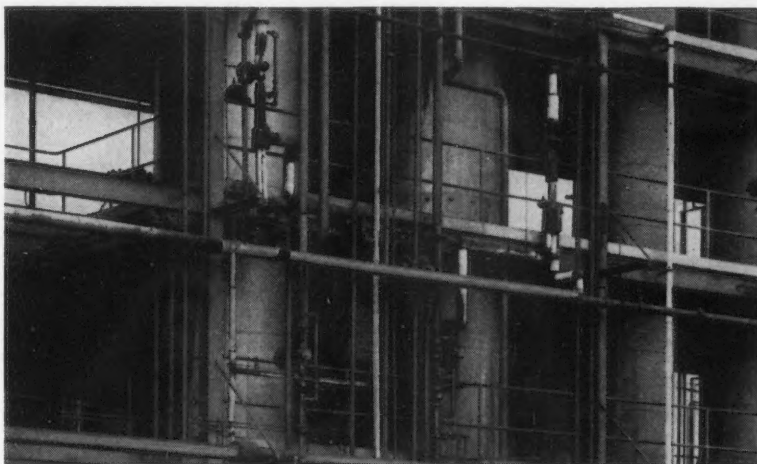
Lero G. Miller, formerly plant manager for Lebanon Steel Foundry, Lebanon, Pa., has been made chief engineer in charge of product.

G. E. Seidel has been appointed executive vice president of Amercoat Corp., South Gate, Cal. He was for many years director of the firm's Central Region at Chicago. His promotion will take him to the firm's California office. **C. G. Munger**, technical director, recently was made vice president of the corporation also. Both are long time and active NACE members.

S. W. Kooperman, Inc., Philadelphia has been named a licensee to apply Insul-Mastic coatings in the Philadelphia area.

ETHYL BENZENE REACTORS LINED WITH CORROSION- RESISTANT SARAN RUBBER

Another example of how SARAN RUBBER
tank lining helps cut cost of handling,
storing or transporting corrosives



The ethyl benzene reactors pictured here have a saran rubber lining under one course of chemical brick. The reactors handle $\frac{1}{3}$ ethyl benzene, $\frac{1}{3}$ higher benzenes, $\frac{1}{3}$ benzene and .3% hydrochloric acid. They have been in service for over three years without appreciable effect on the saran rubber lining in spite of the fact that they operate at a temperature of 110° C.

Saran rubber's high degree of chemical and abrasive resistance makes it the ideal lining for tank cars, storage tanks, tank trailers, processing tanks and other equipment handling corrosive acids, solvents, and other chemicals.

ment handling corrosive acids, solvents, and other chemicals.

Saran rubber lining can be applied easily and economically by experienced saran rubber applicators located strategically throughout the country. We will be glad to advise you as to where and how saran rubber lining can be applied to your best advantage. Get in touch with your nearest Saran Lined Pipe Company office or write direct to The Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan. Offices in New York • Boston • Pittsburgh • Tulsa • Philadelphia • Chicago • Portland • Indianapolis • San Francisco • Houston • Denver • Los Angeles • Seattle • Cleveland • Charleston, S. C. • Toronto • Montreal.

RELATED PRODUCTS

Saran rubber molded parts — stoppers, diaphragms, various-sized moldings for valves, instruments, etc.

Saran lined steel pipe — corrosion-resistant pipe that gives long-term operation with minimum maintenance costs.

Saran Lined Pipe Company
2415 Burdette Avenue, Ferndale, Michigan
Please send me your catalog on Saran Rubber Tank Lining and Saran Rubber Molding Stocks.

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Company _____

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2. TESTING

2.3 Laboratory Methods and Tests

2.3.6, 4.2.1

Initial Stages of Corrosion. J. F. KAYSER. *Metal Treatment*, 19, No. 78, 11 (1952) Mar.

The author has observed microscopically that during its initial stages, atmospheric corrosion appears as a thread-like mark 0.01 mm. long and 0.0002 mm. wide. It rapidly elongates in the initial stages and may turn and cross itself but does not widen. From interferograms, it was established that the marks are depressions approximately 0.00015 mm. deep. These marks were observed on the edges of safety razor blades, ferrous micro samples and on surfaces of roller bearings where corrosion sets in within a few minutes of the generation of the surface and appears to be independent of the process of generation. Illustrations.—INCO.

2.3.7, 3.5.8

Biaxial Fatigue Tests on Flat-Plate Specimens. R. U. BLASER, J. T. TUCKER, AND L. F. KOOSTRA. Babcock & Wilcox Co. Paper before AWS, 32nd Ann. Mtg., Detroit, Oct. 15, 1951. *Welding J.*, 31, No. 3, 161S-168S (1952) Mar.

Discussion of the method and apparatus developed to obtain data on plate materials for pressure vessels under cyclic biaxial stress conditions at minimum cost. In the test, the rectangular plate specimen is supported on edges

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ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.
AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.
BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.
BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.
CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.
CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.
EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.
EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.
INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.
IP—Institute of Petroleum. 26 Portland Place, London W1, England.
JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Hakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.
MI—Metallurgia Italiana. Associazione Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.
MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.
NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.
NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.
NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.
PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.
RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.
RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.
RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.
SE—Stahl Und Eisen, Verlag Stahlseisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postscheck Köln 4110, (22a) Dusseldorf, Germany.
TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.
UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.
ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

held between four hardened steel rods. An experimental stress analysis for a $\frac{3}{4}$ inch thick specimen, methods of detecting initiation of rupture, final appearance of the fatigue fracture, test procedures and results are discussed. Illustrations, 7 references.—INCO.

2.3.7, 3.5.9, 3.5.8

Problems of Metallic Fatigue at High Temperature. THOMAS J. DOLAN. *Metal Progress*, 61, 97-104 (1952) Apr.

Discusses some specific alloys and special tests for severe services at high temperatures. In addition to high mechanical strength at elevated temperature, it is desirable that an alloy exhibit good ductility; resistance to erosion, oxidation, or chemical attack; high fatigue strength; and adequate stability. Data in tabular and graphical form.—BTR.

2.3.7, 5.4.5

Water Resistance of Coatings Containing Nitrogenous Resins. HENRY GRINSFELDER. *Ind. and Eng. Chem.*, 44, 563-568 (1952) Mar.

Presents results of a study undertaken to determine the effect of the nitrogen resin, the alkyd resin, the curing conditions, and the pigment on the water resistance of baked finishes applied to metal surfaces. Data are tabulated and graphed.—BTR.

2.3.9

Nondestructive Materials Testing by Means of Ultrasonics Using the Transit-Time Echo Process. (In German.) ADOLF LUTSCH. *Arch. Eisenhüttenw.*, 23, 57-65 (1952) Jan.-Feb.

Describes process which illustrates how it can be used to determine grain structure and detect defects in metals. Includes tables, graphs, diagrams, photographs, and micrographs. 21 references.—BTR.

2.3.9, 2.3.5, 3.8.2

Electrochemical Studies by the Radioactive-Tracer Method. (Electrolyses in Extremely Dilute Solutions.) (In French.) M. HAUSKINSKY. *Experientia*, 8, 125-132 (1952) April 15.

The ordinary methods of determining electrochemical potentials cease to be applicable in extreme dilution. Energy conditions for formation of very thin electrodeposits (less than a monoatomic layer) can be explored by means of radioactive indicators, following particular polarization curves. Discusses relationship between critical potential defined by such curves and theoretical potential computed from the Nernst equation for the given concentration. Experimental results are collected for critical potentials of deposition of polonium, bismuth, lead, silver, etc., from extremely dilute solutions onto various metals. Shows that the heterogeneity of the electrode surface plays a considerable role in these electrolyses. Explains the overvoltage and undervoltage observed in certain cases, and the exponential form of the polarization curves. 74 references.—BTR.

2.3.9, 2.4.3

X-Ray Fluorescence Analysis: Non-Destructive Testing at Shop Level. F. BEHR. *Steel (U.S.A.)* 130, No. 12, 70-71 (1952) Mar.

Using high intensity X-ray tubes and high efficiency Geiger counters, this non-destructive method identifies each element 3 to 5 minutes after specimens are prepared. A complete fluorescence analysis unit includes four major components:

1) basic X-ray unit; 2) special irradiating X-ray tube; 3) wide-range Geiger counter goniometer, and 4) electronic circuit panel with stripchart recorder. Analysis of low-percentage of any element is limited by the relationship between background radiation intensity and the intensity of the line of the element involved. The analysis causes no change in the specimen. Accuracy of quantitative analysis varies with the nature of the specimen components.—ALL.

2.3.9, 2.4.4

A New Apparatus for Direct Spectro-Chemical Analysis. A. HANS. *Rev. Universelle des Mines, 9th series*, 7, No. 12, 448-451 (1951) Dec.; *Engrs. Digest*, 13, No. 3, 82 (1952) Mar.

Discussion of a new electronic amplifier and recorder for spectro-chemical investigations developed under the auspices of IRSIA (Belgian Institute for Encouragement of Scientific Research in Industry and Agriculture). Nickel content determinations for steels were done using this instrument coupled to a spectrograph. The experimental equipment used is given. Exit slit was 150 microns for line of nickel 3414Å. The negative voltage was 990 volts for cell of the nickel line. In two series of 20 measurements taken with a 24 hours interval on a specimen containing 1.95 nickel the mean errors obtained were 0.67 and 0.62%. Illustrations, 2 references.—INCO.

2.3.9, 3.2.3, 3.4.3

A New Anodic Method for the Transfer of Oxide Films from Heat-Tinted Iron to Glass or Plastic. U. R. EVANS AND R. TOMLINSON. *J. Applied Chem. (London)*, 2, 105-109 (1952) Mar.

The specimen carrying the oxide film to be transferred is cemented to glass, and the metal is dissolved away by anodic action, leaving the film attached to the glass. The area of the pieces transferred can be measured, and the metal (or metals) in the films estimated by microanalysis; alternatively, by transferring to glass coated with petroleum jelly, the wrinkling or curling of the film gives information about stresses present in the films when they are attached to the metal. 11 references.—MR.

2.3.9, 3.4.6, 6.3.6, 6.3.14

Thermobalance Study of Oxidation of Metals. Copper-Tin Alloys. (In Italian.) F. DE CARLI AND N. COLLARI. *Metallurgia Italiana*, 44, 1-5 (1952) Jan.

Presents results of above study, involving continuous photographic recording of weight changes. In the case of copper-tin alloys, a depression in the oxidation is evident for the α -phase, which becomes more and more pronounced as it approaches saturation of the primary solid solution. The γ -phase, on the other hand, is more readily oxidizable, whereas the ϵ -phase is practically non-oxidizable. Believes that further developments of this method may prove to be of interest in the study of industrial heat-resisting alloys. 30 references.—BTR.

2.3.9, 5.3.4

Determination of Sulfate in Chromium Baths Using Radiobarium. STANLEY L. EISLER. *Metal Finishing*, 50, 71-74 (1952) Jan.

Procedure employing radiobarium in the precipitating agent used for determining sulfate concentration. The concentration was found to be inversely

proportional to the counting rate of filtrate containing the excess radiobarium. Test results compared with those of the conventional gravimetric procedure indicated better results could be obtained by using the radiometric method.—MR.

2.3.9, 3.7.3

Radiographic Metallography. (In French.) C. CHAUSSIN. *Metallurgie et la Construction mecanique*, 83, 35-37, 99-101 (1952) Jan., Feb.

Production, characteristics, and techniques. Applications of X- and γ -rays in the testing of weldments. Sensitivity and value of the methods, and the nature and the production of the rays.—MR.

2.3.9, 8.10.2

Nuclear Reaction Radiography and Auto-Radiography of Metals. M. HILLERT. *Metal Treatment*, 19, No. 78, 135-137 (1952) Mar.

A brief description of the new radiographic method called nuclear reaction radiography with particular reference to the examination of an iron-boron alloy is given. Discussion of controlling factors for good results of autoradiography includes the importance of resolving power and radioactive track analysis which was used to determine the lead distribution in a steel ingot. Illustrations, 6 references.—INCO.

2.3.9, 8.10.2, 3.7.1

Radioisotopes Aid Metallurgy. Part I and II. GORDON H. GUEST. *Canadian Metals*, 15, 16-17, 18-19 (1952) Feb. Mar.

Part I: The role of radio-isotopes in the study of metals, their characteristics and application in diffusion processes, corrosion studies, steelmaking, flotation, and radiography.

Part II: Concludes review of present and potential applications in corrosion, steelmaking, and other problems. 16 references.—MR.

3. CHARACTERISTIC CORROSION PHENOMENA

3.6 Electrochemical Effects

3.6.5, 6.4.2

The Electrochemical Properties of Aluminum (Part 1). H. HATAMOTO AND K. MIZUNO. *Light Metals (Japan)*, No. 3, 40-42 (1952) May.

The measurements of the potential of aluminum by vacuum tube potentiometer which is newly originated were performed. Results are as follows: 1) The potential is always inclined to electro-positive. 2) The potential of high purity aluminum is more electro-positive than that of low purity. 3) The potential is affected by the heat treatment of samples.—JSPS.

3.6.5, 6.2.5, 4.6.11, 2.3.5

Some Observations of the Potentials of Stainless Steels in Flowing Sea Water. K. M. HUSTON AND R. B. TEEL. Paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, 8, No. 7, 251-256 (1952) July.

Available information on the EMF potentials of stainless steels has been limited to a relatively few grades. There has been no information on neither the

free-machining grades nor the new alloys. This article reports potentials in sea water of nine standard grades and three new grades of stainless steel. The effect of heat treatment, free machining element and crevice corrosion on the EMF potentials are discussed. The relation of these potential values to those of other common alloys is indicated.

The testing equipment set-up at the Harbor Island Marine Test Station is described and illustrated by photographs.

3.6.5, 6.4.2, 6.4.4

Researches on the Electrochemical Properties of Al-Mg Alloys. H. HATAMOTO. *Light Metals* (Japan), No. 3, 43-46 1952 May.

The relation between the potential and corrosion behavior of aluminum-magnesium alloys containing 0.46-3.43% of magnesium in 3% sodium chloride +0.1% hydrogen peroxide solution were studied.—JSPS.

3.6.6, 3.8.2

Electrochemical Examination of the Mild-Steel/Stainless Steel Galvanic Couple. L. FELLONI AND A. INDELLI. *Chimica e Industria* (Milan), 33, 348-352 (1951) June (In Italian); *J. Iron Steel Inst.*, 170, No. 1, 84 (1952) Jan.

In the mild-steel/stainless steel couple the stainless is always the cathode whatever the conditions of acidity of the attacking agent. This remains true even if chromites and sulphuric acid are added to the medium. Coupling mild steel to stainless steel nearly always reduces the resistance to corrosion of one or the other metal and in some cases of both. For certain concentrations of acid and chromite the behavior of the stainless steel changes from a passive (when isolated) to a completely active state when brought into contact with mild steel. The causes are discussed.—INCO.

3.6.6, 6.3.15, 2.3.5

Effect of Titanium in Galvanic Corrosion. HENRY PAIGE AND SARA J. KETCHAM. *Corrosion*, 8, No. 12, 413-416 (1952) Dec.

While titanium has remarkable corrosion resistance in many environments, other factors have to be considered before this metal can be used in naval aircraft construction as a replacement for stainless steels. Among these are galvanic effects which could result from contact with dissimilar metals in marine atmospheres. A series of laboratory tests has been performed in which various metals have been coupled to either stainless steel or titanium in normal sodium chloride. Electrode potential studies have also been made on specimens given different surface treatments. Comparison of the data indicates that the electrochemical behavior of titanium and stainless steel is similar under the test conditions. Mechanical testing of heat treated specimens reveals that exposure to oxidizing conditions above 1000 degrees F has a deleterious effect on the ductility of titanium as well as its resistance to stress-corrosion conditions.

3.6.6, 5.2.1

The Electrical Nature of Corrosion and Cathodic Protection. H. D. HOLLER. *Electrical Engineering*, 71, 367-373 (1952) April.

This study of corrosion from the electrical standpoint is an evaluation of the behavior of galvanic couples in accordance with the laws of electricity. 16 references.—MR.

3.6.6, 5.3.2, 6.3.6

Galvanic Behavior of Tin Dipped Coatings on Copper Alloys. F. L. LAQUE, Inc. *Corrosion* (News Section), 8, No. 4, Topic of the Month 1 (1952) April.

Tin and tin alloy coatings on copper and copper alloys are expected to be anodic to copper in most environments, but under some circumstances they become cathodic and accelerate corrosion in the form of pitting. These tin coatings, according to the author can form corrosion product films that can make them more noble without any effect due to the alloy layer near the interface between the coating and the basic metal. This is shown in examples of hot dipped tin on 70-30 copper-nickel and wiped solder coating on Monel immersed in flowing sea water at Kure Beach.—INCO.

3.6.6, 6.4.2, 6.3.6

Aluminum-Copper Clamps for Overhead Lines. (In German.) G. DASSETTO. *Aluminum*, 28, 31-32 (1952) Jan.-Feb.

Galvanic corrosion occurs when aluminum and copper come in contact, especially in the presence of moisture. Describes method of prevention in which a clamp of 99.5% aluminum is used as "material reserve," being attacked instead of the aluminum wire.—BTR.

3.7 Metallurgical Effects

3.7.4, 6.3.5

Studies of Metal Structures Boosts Stainless Steel Use. A. B. Kinzel. (Union Carbide and Carbon Res. Labs.) Paper before AIME., Ann. Mtg. *Blast Furnace Steel Plant*, 40, No. 4, 70 (1952) Apr.

Author in Howe Memorial Lecture states that studies of crystal structure of metals, made at high magnifications with the electron microscope, may lead to a substantial increase in the consumption of stainless steels. In studying the behavior of these steels, with particular attention paid to the shape and distribution of chromium carbides, two important developments resulted. One is that control of carbon can be obtained by the use of a new type of extra-low-carbon ferro-chromium. Secondly, the use of manganese and nitrogen is becoming increasingly important in chromium stainless steels for many structural applications.—INCO.

3.7.2., 6.2.2

Influence of Phosphorus on the Oxidation of Iron at High Temperatures. (In Italian). Nello Collari. *Metallurgia Italiana*, 44, 97-102 (1952) Mar.

Mechanism of the above was studied. It was found that the metalloid can develop a remarkable protective action, due to the formation of an iron-phosphate rich layer between the metal surface and the exterior oxidized layers. Shows that the layer of phosphate governs the oxidation phenomenon, reducing the diffusion activity of the iron. Micrographs and tables.—BTR.

3.7.3

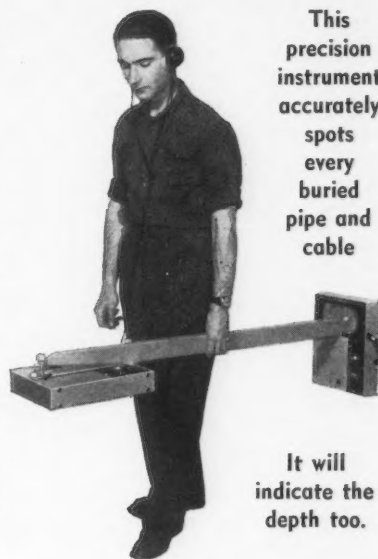
How to Select Brazing and Soldering Materials. H. R. Clauser. *Materials & Methods*, 35, No. 3, 105-120 (1952) Mar.

Aid in solving the selection problem by presenting a broad view of the types, characteristics and use of the available brazing and soldering materials. This manual covers brazing alloys and fluxes including silver-brazing alloys, copper

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and copper alloys such as copper-nickel alloys; soft solders and fluxes; and brazing alloys and solders for various metals such as carbon and low-alloy steels, stainless steel, cast steels and irons, copper and copper alloys, nickel and nickel alloys, titanium, aluminum and aluminum alloys, magnesium and magnesium alloys and others. Brazing alloys for joining various similar and dissimilar materials are given in table form. Tables and illustrations.—INCO.

3.7.3, 3.5.9, 6.5

Welded Joints Between Dissimilar Metals in High-Temperature Service. R. W. Emerson and W. R. Hutchinson. (Pittsburgh Piping and Equipment Co.) Paper before AWS, 32nd Ann. Mtg., Detroit, Oct. 15, 1951. *Welding J.*, **31**, No. 3, 126s-141s (1952) Mar.

Time and temperature effects on the structural stability of welded joints between austenitic and ferritic materials using austenitic electrodes, with reference to carbon migration, depletion and recrystallization of the ferritic base metal at the austenitic weld metal interface and effects on the mechanical properties of such joints were studied. The relative carbide stabilizing effects of chromium, vanadium, and titanium when present in the ferritic base metal and of a vanadium-bearing weld deposit when used as a butting on carbon, and chromium-molybdenum materials before welding with austenitic electrodes are given. The nickel content of chromium-molybdenum plates is tabulated. The analysis of the plates used were: 19 chromium—9 nickel-cobalt (Type 347), 18 chromium—12 nickel—2 molybdenum (Type 316), 25 chromium—12 nickel (Type 309), and 25 chromium—20 nickel (Type 310). Mechanical properties of test welds after 5,000 hours heating and results of metallographic observations before and after 5,000 hours heating are discussed with illustrations. Tables, 5 references. INCO.

3.7.3, 6.2.5

Corrosion-Free Stainless Welds. G. E. Linnert, Armco Steel Corp. *Welding Engr.*, **37**, No. 1, 51-53 (1952) Jan.

Resistance to intergranular corrosion is obtained by the use of extra-low carbon, chromium-nickel stainless steels. These ELC steels are substitutes for niobium-stabilized stainless steels where service temperatures are below 800°F. Weld joint corrosion, properties of ELC steels and properties of welded joints are discussed. Stresses resistance to intergranular corrosion. Eliminates post-weld annealing, simplifies field repair, reduces metal costs, and conserves niobium. Tables of properties are included.—INCO.

3.7.3, 6.2.5, 3.2.2

Welding Stainless Steels Without Carbide Precipitation. J. A. Goodford and D. W. Kaufmann. *Industry and Welding*, **25**, 31-32, 73 (1952) Mar.

Recommends and describes ways of rapid cooling of heat-affected zone promptly after welding to reduce chances of subsequent intergranular corrosion.—BTR.

3.7.3, 6.3.15

Resistance and Fusion Welding of Titanium and Its Alloys. E. F. Holt and W. H. Moore. P. R. Mallory and Co., Inc. *Welding J.*, **31**, No. 3, 213-216 (1952) Mar.

Because of a higher strength-weight

ratio, resistance to corrosion and excellent properties at temperatures up to 1000°F., titanium is being considered as a replacement for alloy and stainless steel. Properties of titanium, titanium alloys and other structural alloys, such as Type 302 stainless steel, are tabulated. Titanium has been successfully welded by resistance, spot and flash, and inert-gas shielded-arc welding. Techniques and optimum welding conditions are discussed. Low electrical and thermal conductivity of titanium and its alloys, coupled with low coefficient of thermal expansion contribute to ease of spot welding. One manufacturer flash welds titanium rings for jet aircraft engines. Brittleness, although the tensile strength is high, appears characteristic of inert-gas-shield-arc welds. Best results were obtained in inert-gas-shield-arc welding by using titanium with less than 0.25 C. Illustrations, 14 references.—INCO.

3.7.3, 7.7, 6.3.10

Improved Electrical Resistance Alloy. *Engineers' Digest*, **13**, No. 3 93, (1952) Mar.

Karma, the new nickel-chromium alloy manufactured by British Driver-Harris Co., Ltd. of Manchester, has higher ohmic values, more stable resistance, low thermal e.m.f., superior resistance to oxidation and a higher tensile strength. Its advantages are given. Karma can be soldered, brazed or welded and arrangements are being made to supply it with insulations such as enamel and fabric coverings. It is available in wire sizes down to 0.001 in diameter.—INCO.

3.7.3, 8.9.1, 7.10

Hermetic Welding Stops Internal Corrosion. B. Gross. *The Iron Age*, **169**, No. 6, 142-144, (1952) Feb. 7.

Hermetic welding has prevented internal corrosion of tubular air-craft structures such as engine mounts. Condensed water inside welded tubular structures which does not drain out, oxygen and ozone from the air, and temperature changes, provide the environment for breakdown of internal coatings and subsequent corrosion of the parts. Adequate sealing of the parts will prevent leakage through drive screw holes etc. Three methods are used to test the structures. In the hot water method the parts are immersed in a tank of clear water at about 200° F. to obtain air pressure, and leaks are detected by the rising bubbles. The pressure and solvent method is sensitive and may be used to locate leaks in visible areas. Inert gas or dry air is injected through a test hole at gauge pressures between 80 and 100 psi. Solvent is then poured over each part of the structure. Leakage is detected by observing a sheet of mist produced whenever the solvent flows over small cracks or pores. The halide detector method locates minute flaws. The structure is placed in a test box and the lid closed. Freon No. 12 is injected into the structure through a test hole until 15± psi. is obtained. Inert gas or dry air is added to obtain a total of 60-80 lbs. gauge pressure. A halide detector is used to sample the air in the box. If there is no indication of leakage, after full pressure within the tube has been reached, the structure is acceptable. After removal of the structure from the test ring, the test hole is sealed by arc welding.—ALL.

3.7.4, 2.3.9, 6.3.4, 6.3.11

A New Superlattice in Co-Pt Alloys.

A. H. Geisler and D. L. Martin. Gen Electric Res. Lab. *J. Applied Physics*, **23**, No. 3, 375 (1952) Mar.

Investigation of the structure of an alloy containing 30 cobalt. X-ray diffraction analysis shows that this alloy formed superlattice of the type expected for PtCo, face-centered cubic with cobalt atoms on the corner sites and platinum atoms on the face centers analogous to Cu₃Au. In view of the observations of FePt₃, FePt, and Fe₃Pt in the iron-platinum system one might expect to find similar phases in the cobalt-platinum alloys. Transformation temperature and lattice parameter phase of the alloy are discussed. 4 references.—INCO.

3.7.4, 5.3.4

Structure of Electrodeposits. J. J. Dale. Paper before Australian Inst. of Metals, Phys. Metall. Div., 1949. *Metal Progress*, **61**, No. 3, 106-1, (1952) Mar.

The structure of electrodeposits are classified into two groups, normal and abnormal structures. The common form is columnar such as nickel when deposited from an acid bath. Nodular shapes and banded deposits are less common forms with the conical and acicular crystals and fan-like groups being listed as variants. A discussion on defects and abnormalities includes large nodules, trees, pits, blisters, cracks, burned and powdery deposits. Factors affecting growth of electrodeposits are tabulated. Nickel plating solutions within a certain pH range are exceptions to the rule that an increase in current density favors reduced grain size. Observations of bright-nickel deposits showed no consistency so the brightening action must be due to another factor. The alloy deposit of tungsten with iron, cobalt, and nickel is considered. Discussion of pitting in nickel deposits is given.—INCO.

3.7.4, 6.2.2, 2.3.4

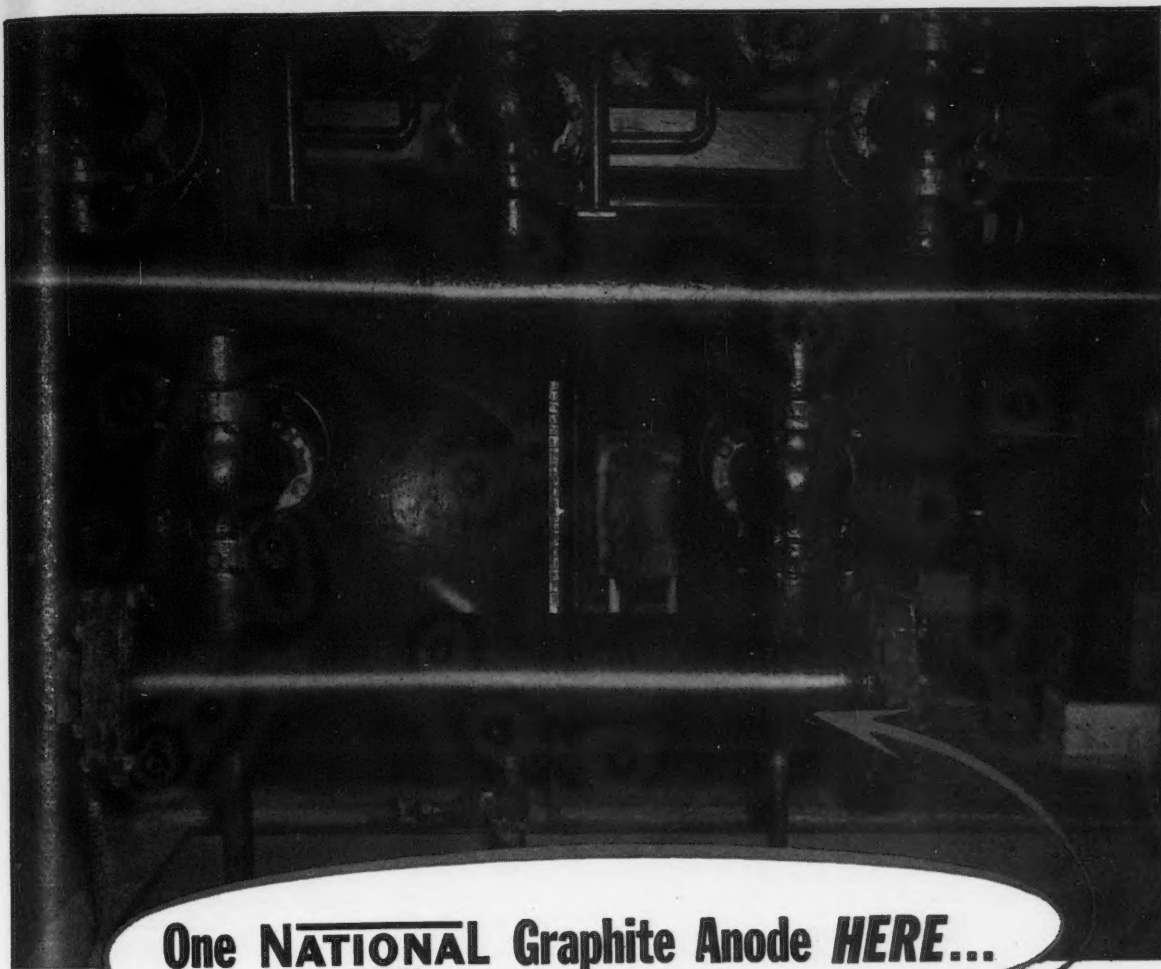
Notes on the Formation of Nodular Graphite in Magnesium Treated Cast Iron. F. Munoz del Corral. *Inst. hierro y acero*, **4**, 227-229 (1951) July-Sept.; *J. Iron Steel Inst.*, **170**, Pt. 3, 293, (1952) Mar.

New aspect of the formation of nodular graphite and the major importance of the phenomena in the intermediate phases in the formation of the nodular structure are indicated. A mechanism for nodules, whereby they germinate in preferred regions of the austenite-cementite boundaries, and grow by precipitation of carbon from the austenite and progressive solution of the cementite in the austenite is suggested.—INCO.

3.7.4, 6.2.2, 2.3.4

Some Trends in the Protection of Nodular Cast Iron. J. A. Bressel Egido. *Inst. hierro y acero*, **4**, 112-130, 197-208; (1951) Apr.-June, July-Sept. (In Spanish). *J. Iron and Steel Inst.*, **170**, Pt. 3, 293 (1952) Mar.

American and British methods of making nodular cast iron with magnesium are surveyed. Trials carried out at the Saragossa Works of the Ebro. Eng. Foundries are described. Preliminary tests, even with metal containing up to 0.25% sulfur indicated the possibility of producing this material in Spain on a commercial scale. Details are given of the charge and method of working, and of forging tests. Structure and mechanical properties are described as well as a method of determining magnesium in nodular cast iron using 8-hydroxyquinoline.—INCO.



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3.7.4, 6.2.5, 3.2.2

Depletion of Grain Boundaries of Stainless Steels in Chromium as Cause of Intergranular Corrosion. I. A. LEVIN. Doklady Akad. Nauk SSSR, 83, No. 5, 701-704 (1952).

Presentation of experimental data which are at variance with the assumption that intergranular attack of stainless steel is caused by depletion of the grain boundaries in chromium. Compositions used in study: Various iron-chromium alloys containing 0.04% carbon. Corrosive media used: phosphoric acid and nitric acid solutions. Anodic polarization curves for chromium steels with various chromium contents in 30% nitric acid. Rejection of chromium impoverishment theory on four counts—(a) behavior of stainless steels in anodic polarization; (b) in the light of polarographic analysis data on corrosion products migrating into corrosive medium; (c) behavior in 30% nitric acid and passivation of iron in the particular systems; and (d) calculated activation energies of diffusion of chromium and carbon in stainless steel. Translation available from Henry Brucher, Technical Translation, P. O. Box 157, Altadena, California. Price, \$4.20.

3.7.4, 6.3.6, 3.5.9

Observations on the Structure and Properties of Wrought Copper-Aluminum-Nickel-Iron Alloys. Paper No. 1364. M. COOK, W. P. FENTIMAN AND E. DAVIS. *J. Inst. Metals*, 80, Pt. 8, 419-429 (1952) Apr.

Copper alloys containing 8 to 12 aluminum and 4 to 6 each of nickel and iron were studied. Four phases, α , β , δ and K, were identified, with random face-centered cubic, random body-centered cubic, γ -brass type, and ordered body-centered cubic structures, respectively, and the phase fields for equilibrium conditions have been approximately determined. Structurally, the alloys can be divided into 3 classes; alloys containing 8 to 9 aluminum which, consisting of α and β at 1000° C., change to α and K at lower temperatures; alloys containing 10 aluminum, consisting of β at 1000° C., α , β , and K between 800 and 900° C., and α and K at lower temperatures; and alloys containing 11 to 12 aluminum, consisting of β at 1000° C., changing from $\beta + K$ to $\alpha + \beta + K$ over the range 800–600° C. and finally changing to $\alpha + K + \delta$. The mechanical properties of alloys containing 8, 10 and 12 aluminum with 5 each of nickel and iron, representative of the 3 classes were determined in the quenched, quenched and tempered, hot-rolled, and hot-rolled and annealed conditions, and were related to the structures. Optimum properties were obtained with the 10-5-5 alloy. Photomicrographs show typical structures.—INCO.

3.8 Miscellaneous Principles

3.8.2

Electrolysis of Phosphoric Acid Between Copper Electrodes. Case of Weak Current Densities. (In French.) DENISE LAFORGUE-KANTZER. *Compt. rend.*, 234, 1284-1287 (1952) Mar. 17.

Experimental and theoretical discussion of the mechanism of anodic dissolution of copper at very weak current densities, particularly when the copper ion concentration is high. Graphs.—MR.

3.8.2, 1.6

Textbook of Electrochemistry, Volume II. By G. KORTUM AND J. O'M. BOCKRIS. 530 pages plus xiii. $6\frac{3}{4} \times 9\frac{3}{8}$ inches, cloth bound. (1951). Elsevier Publishing Co. 402 Lovett Boulevard, Houston, Tex. Per Copy, \$10.

This volume II (Vol. 1 reviewed in *Corrosion*, 7, No. 11, Page 16 News Section, November, 1951) of the textbook by Kortum, professor of physical chemistry at Tübingen University and Bockris, lecturer in physical chemistry at the Imperial College of Science and Technology, University of London, begins with Chapter X. It contains the subject index. Chapter headings are Electrical Phenomena at Interfaces, Irreversible Electrode Processes, Electrochemistry of Gases, Experimental Methods of Electrochemistry, Tables of Certain Physico-Chemical Properties.

The tables are divided into four principal sets: 1.) Universal physical constants and ratios. 2.) Data concerning physical properties of chemical materials e.g., refractivity, dipole moment. 3.) Functions concerned in the physical chemistry of electrolytes, e.g. conductance, activity coefficients. 4.) Data concerned with electrode processes, e.g., standard and redox electrode potentials and data on overpotential. These tables occupy 152 pages of the book. Problems related to the chapters of the book are in numerical order in a section on examples.

3.8.2, 3.8.3, 3.4.6

The Influence of Oxide Layers, as Well as of Chlorine Ions Upon the Electrochemical Behavior of Passive Iron, Chromium and Iron-Chromium in Dilute Nitric Acid. (In German.) THEO HEUMANN AND WOLFGANG ROSENER. *Z. Metallkunde*, 43, 42-44 (1952) Feb.

Reports on tests with chromium and on an iron alloy containing 20% chromium, as well as on alloys containing less chromium. Polarization curves are presented and stability of the oxide film is discussed. 10 references.—BTR.

3.8.2, 6.4.4, 4.3.2

The Dissolution of Magnesium in Hydrochloric Acid. B. ROALD AND W. BECK. *J. Electrochem. Soc.*, 98, No. 7, 277-290 (1951) July.

The dissolution of magnesium in hydrochloric acid has been studied by measuring dissolution rates and electrode potentials as functions of acid concentration, rate of agitation, temperature, external polarization, alloy composition, and additions to the acid solution. The dissolution rate measurements offer evidence in favor of a diffusion controlled reaction. By studying the dissolution process at acid concentrations up to 1.6 normal it has been possible to evaluate the stirring effect of the hydrogen bubbles which are evolved. The changes in the electrode potential with the acid concentration have been shown to depend on a deposition of low overvoltage impurities (iron, copper, manganese, etc.) on the surface of the metal. When this condition is taken into account, the observed electrode potentials are readily explained in terms of the electrochemical theory of corrosion. The effect of external polarization (anodic and cathodic) in reducing local action has been related to the effect of the applied emf on the rate of transfer of hydrogen ions to the surface of the metal by diffusion and migration. The results are in accord with

the view that the dissolution of metals is electrochemical in nature, even in cases such as the dissolution of magnesium in hydrochloric acid where stationary local cells are absent, and the dissolution rate is diffusion controlled. (Author's summary).—ALL.

3.8.4, 6.3.2

The Solubility of Cadmium in Mixtures of Cadmium Chloride With Other Chlorides. DANIEL CUBICCIOTTI. *J. Am. Chem. Soc.*, 74, 1198-1200 (1952) Mar. 5.

Solubility of cadmium in mixtures of cadmium chloride with the chlorides of potassium, calcium, cerium, manganese, magnesium, and zinc was determined at 740° C. Addition of any of these salts reduced the solubility. Effectiveness in reducing solubility is compared with anion-to-cation ratio of the salt and electropositivity of the metal of the cation.—BTR.

3.8.4, 6.3.11

The Rate of Corrosion of Silver in Ferric Perchlorate Solutions. CECIL V. KING AND FRANCES S. LANG. New York University. Jan. 3, 1952. 25 pp. (NYO-630.)

Silver dissolves much more slowly in ferric perchlorate and nitrate than in ferric sulfate solutions. A detailed study of the rate in perchlorate solutions has been made, with the effect of concentration of ferric, ferrous and silver ions, of other salts including sulfates, of stirring speed, temperature and electrical polarization. Two factors are responsible for the difference in rates: a) silver perchlorate is more strongly absorbed on silver than silver sulfate is, and b) a sulfato-ferric complex ion reacts more rapidly than the normal hydrated ferric ion. Spectrophotometric evidence is given for the existence of the sulfato-ferric ion. (Author).—NSA.

4. CORROSIVE ENVIRONMENTS

4.2 Atmospheric

4.2.3, 1.2.5, 8.10.2

Some Experience With Cupola Spark and Dust Arresters. W. Y. BUCHANAN. Brit. Cast Iron Research Assoc., *J. Research and Development*, 4, 272-279; disc. 279-282 (1952) Feb.

Considers various types of impurities given off from cupola stacks. Outlines the development and improvements in the design of wet spark arresters which have taken place in recent years, chiefly in America. In an early design of arrester, accelerated corrosion of the pipes took place due to concentrations of sulfur compounds in the circulated water. Means of minimizing the corrosion problem are described.—BTR.

4.3 Chemicals, Inorganic

4.3.2, 2.1.1, 6.3.2

The Dissolution of Metals Over the Temperature Range of 25 to -60°. Part II. The Dissolution of Cadmium in Hydrochloric Acid-Methyl Alcohol-Water Solutions. A. B. GARRETT AND J. R. HEIKS. *J. Phys. Chem.*, 56, 449-451 (1952) Apr.

Data were obtained for the above under static and dynamic conditions, in the presence of a depolarizer over the temperature range of 25 to -60° C. Energy of activation of the static depo-

larized process is in the order of 4000 cal./mole and of the non-depolarized process is about 10,000 cal./mole. The non-depolarized dissolution process is first order with respect to the acid concentration. Graphs and tables.—BTR.

4.3.5, 3.8.4

Molten Sulphur; Corrosion of Steel at Temperatures Up to 450° C. *Iron and Steel*, 25, 137 (1952) April.

Deals with the mechanism and rate law for the corrosion of metals with the formation of sulfides. The progress of corrosion was recorded conductometrically. Weight-loss tests were made, and samples of the sulfide scale were examined by microscopic and X-ray methods.—BTR.

4.3.5, 4.3.2, 4.4.1, 5.11, 6.1

Corrosion by Fluorine and Fluorine Compounds. RALPH LANDAU. A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, 8, No. 8, 283-288 (1952) Aug.

The extreme reactivity of fluorine paradoxically brings to its compounds their most attractive properties—resistance to chemical attack. Because it tends to displace other elements and because no other element is sufficiently reactive to displace fluorine, fluorine compounds become chemically inert. While fluorine is near oxygen and chlorine in the periodic table its 2.85 electronegativity is the highest known and makes it tend to displace them from their compounds. The heat of reaction of fluorine is much greater than for oxygen or chlorine, and while metals that resist oxidation also may resist fluorine, contaminants, particularly organic materials, may react so rapidly as to initiate ignition of backing metal.

Materials of construction useful in handling fluorine are given, with indications of their limitations as to concentration, heat and thickness and specific recommendations on general design factors are itemized.

General characteristics of the fluorocarbons, and some specific fluorocarbon materials are described.

Some safety recommendations are included.

4.3.5, 6.3.10, 3.5.9

The Development of Fluorine. H. R. LECHE. Imperial Chemical Industries Ltd. *Research* (London), 5, No. 3, 108-115 (1952) Mar.

Article describes common methods used for production of fluorine and practical aspects of handling it. High and medium temperature cells, present position on fluorine production and industrial development are discussed. Electrolytes of concentrated solution, approximately KF: 2HF, at temperatures around 100° C, are contained in vessels of mild steel. A high temperature installation consists of a Monel metal container as cathode, and graphite anodes enclosed in a Monel wire screen. There was some corrosion in the cell, even Monel corroded, though the effect was not serious. A nickel anode in a medium temperature cell gives a straight forward method of making fluorine and hydrofluoric acid. Corrosion is negligible up to 250° C, and not very great up to 400° C. Nickel shows an excellent resistance up to 600° C and it can be used for short periods up to 700° C in fluorine. Photo-

graphs and 27 references are included.—INCO.

4.3.7, 6.4.2

Mercury Cited as Cause in Unusual Corrosion Problems. *Chem. Eng. News.*, 30, No. 13, 1290-1292 (1952) Mar. 31.

Cases of sudden and unusual corrosion of nonferrous alloys may be due to the presence of mercury and its compounds. Mr. H. Brown of the Aluminum Company of America stated at the National Association of Corrosion Engineers Convention. Chemical spectrographic techniques showed the presence of small globules of mercury on aluminum equipment which corroded after a long period of service. The vapor pressure of metallic mercury is sufficient to permit mercury vapors to pass through systems and alloy with many commercial metals. Where stress cracking is encountered this amalgamation may be the cause. Mr. Brown presented data to show that as little as 0.5 part per million of mercury compounds can cause serious corrosion.—ALL.

4.3.7, 7.6.1, 7.2, 7.3

Equipment for Use With High-Strength Hydrogen Peroxide. NOAH S. DAVIS, JR., AND JOHN H. KEEFE, JR. *J. Am. Rocket Soc.*, 22, 63-69 (1952) Mar.-Apr.

Results of compatibility tests on various materials, including metals, plastics, and lubricants, are presented. General equipment-design considerations and methods of preparing the equipment for hydrogen-peroxide service are outlined. Examples of the following equipment are presented and discussed: pumps, containers, piping, flexible hose, valves, and reactors.—BTR.

4.4 Chemicals, Organic

4.4.2, 7.6.1, 6.2.5

Improvements in the Simple Distillation of Fatty Acids by Continuous Methods. R. W. BERGER. Wurster & Sanger Inc. Paper before Am. Oil Chemists' Soc., 25th Fall Mtg., Chicago, Oct. 8-11, 1951. *J. Am. Oil Chemists' Soc.*, 29, No. 3, 81-87 (1952) Mar.

The surfaces of all equipment, piping, pumps and instruments contracted by the fatty acids are constructed of stainless steel. AISI type 316 is the most generally applicable alloy. Except for relatively thin sections, the intergranular precipitation of carbides at welding temperatures destroys the corrosion resistant properties of this alloy. Since equipment involved is complex, a carbide resolubilization heat treatment after fabrication is not practicable. Best thing is to use a special extra low carbon grade of this alloy so that the small amount of carbides precipitated during welding do not significantly affect the corrosion resistance. Stainless steel does not withstand the attack of the acids of crude tall oil at elevated temperatures, and if distillation of this material is contemplated, the equipment operated at high temperature should be of Inconel. Both stainless steel and Inconel are attacked at high temperatures by mineral acids or their organic compounds in the crude fatty acids even though present only in trace amount, and careful testing of all feed stocks is recommended. To minimize corrosion from this source a short boil with dilute soda ash usually is sufficient.—INCO.

4.4.7, 2.3.4, 6.2.2

A Test on the Corrosion of Iron by Lower-Temperature Treated Coal Tar. S. ANDO AND S. YAMAMOTO. *Coal Tar* (Japan), 4, No. 7, 208-210 (1952) July.

The corrosion rates of iron by each fraction of coal tar treated at lower temperatures were determined by a laboratory method.

In this experiment, iron specimens, soaked in each fraction of the coal tar within a flask with a reflux condenser, were heated at the boiling point for 6-8 hours, and then the weight loss was determined.

By the results obtained with the various fractions, the corrosion rate increased considerably when the treating temperature of the fraction become more than about 240° C.

In addition, the corrosion rate of 13% chromium steel was decidedly smaller than that of iron and steel.—JSPS.

4.5 Soil

4.5.1, 5.1, 1.6, 1.2.1, 1.7.1

Electrolysis Control Handbook. (Denshoku Boshi Hand Book. In Japanese.) 466 pages, 355 figures. Edited by Electrolysis Control Research Committee (Denshoku Boshi Kenkyu Iinkai). Published by the Institute of Electrical Engineers of Japan, Tokyo, April 5, 1952. Price per copy, plus postage—Yen 600.

A thoroughly revised and enlarged edition of Denshoku Boshi Soten (Electrolysis Control Guide Book) published in 1937.

Modern theories and practices concerning electrolysis control are summarized. Practical examples and tabulated data are included to increase the value of the book to research and practical workers.

Included are statistics on corrosion damage to communication and power cables in Japan, theory of underground corrosion, analysis of stray current distribution from railways, rail bonding, railway current feeding systems, measurement of stray currents, cable sheath and pipe line currents.

Material on chemical analysis of earth, underground water and deposits on corroded metals, methods of mitigating corrosion on lead sheaths and pipe lines, cathodic protection, inhibitors, protective coverings, estimating corrosivity of underground water, and recommended specifications for cable sheaths (JEC-121A, JEC-121B, JEC-121C, April, 1951).

The book also gives current governmental regulations to protect underground structures from corrosion, examples of similar regulations in other countries, such as Germany (VDE 1933), Switzerland, Britain (1920), France (1911), Spain (1900), recommendations by CCIF in Paris (1949).

Organization of the Electrolysis Control Research Committee in Japan, its members and activities also is included.

4.6 Water and Steam

4.6.6, 2.3.5, 5.8.2, 3.6.2

Corrosion Due to Tuberculation in Water Systems. 1. The Effect of Calgon on the Potential of Iron Electrodes in Differential Aeration Cells with Running Tap Water. J. L. MANSA AND WAC-LAW SZYBALSKI. *Corrosion*, 8, No. 11, 381-390 (1952) Nov.

Influence of Calgon on potentials of

electrodes in a differential aeration cell designed to approximate the conditions inside a pipe with running tap water is studied. Calgon decreases cathode potential adsorption, thereby inhibiting oxygen access to the surface, while potential of the anode increases because Calgon interferes with anodic depletion of the oxygen. Corrosion current decreases as a result of these two effects and also because of the increasing internal resistance of the cell resulting from formation layers of Calgon and of corrosion products with low electrical conductivity. Differential layers of corrosion products in areas of greater water flow limit oxygen access and cause tuberculation and corrosion to cease.

Tests with zinc-iron electrodes in a differential aeration cell indicate corrosion in the zinc may follow the same pattern as that of iron. Calgon depresses the difference of potentials between anode and cathode as in the cell with iron electrodes and for the same reasons. After some weeks zinc becomes cathodic to iron in the cell where zinc surface is exposed to aerated water and the iron electrode is in stagnant water. Potential of the zinc decreases as rate of flow of water decreases. Aeration cells with zinc, iron and copper electrodes are discussed.

4.6.7, 6.2.2, 3.4.8

Corrosion and Formation of a Negative Ferric Hydrate Sol. (In French.) M. O. CHARMANDARIAN AND N. N. ANDRONIKOVA. *Bull. Soc. Chim. France*, 99-101, 1952, Jan., Feb.

Corrosion of iron, in the presence of gum arabic, in water and in solutions of sodium chloride and sodium sulfate, is accompanied by formation of the negative sol. of ferric hydrate. Corrosion depends on amount of gum arabic, and on concentration of the solutions. Data are tabulated.—BTR.

4.7 Molten Metals

4.7

Viscosities of Liquid Lithium, Rubidium and Caesium. E. N. DA C. ANDRADE AND E. R. DOBBS. *Proc. Roy. Soc. (London)*, 211, A, 12-30 (1952) Feb. 7.

Oscillating-sphere method is applied to find viscosities of liquid lithium, rubidium, cesium. Special precautions for handling liquid lithium are detailed, with precise description of apparatus. Bifilar W wire suspension used for nickel-lined copper sphere is necessary in view of liquid lithium attack on glass and many metals. Reference is made to nickel cylinder for charging liquid lithium into sphere, two radiation shields consisting of bright stainless steel disks, Nichrome-Eureka thermocouple for temperature measurement, and various nickel and platinum vanes to prevent rotation of liquids in spheres.—INCO.

4.7, 3.5.9, 2.3.4, 7.4.2

Liquid Sodium—A Noncorrosive Coolant. R. F. KOENIG AND S. R. VANDERBERG. *Metal Progress*, 61, 71-75 (1952) Mar.

Presents recent data on the corrosive properties of liquid sodium in contact with stainless steels and high-nickel alloys; and describes several test methods. The most fundamental approach employs solubility studies. Small containers of the material being tested are filled with sodium and samples of the sodium are removed after suitable periods of heating. Chemical

analysis of the samples provides solubility data. From this and metallographic examination of the containers, an indication of rate, extent, and manner of attack was obtained. Describes other methods, including those revealing effect on mechanical properties.—BTR.

5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.2, 7.5.2, 8.3.5

Technical Background for Further Tin Conservation. R. R. HARTWELL. *Modern Lithography*, 20, 49, 51, 53, 113, 115; 61, 63 (1952) Mar., Apr.

Discusses the above in relation to NPA Order M-25 with special reference to electrolytic tinplate for food containers, and substitutes for hot-dipped plate. Considers relative corrosion resistance to different foods of different thicknesses of tin plating.—BTR.

5.3.4

Vapor Deposition May Solve Today's Coating Problems. I. E. CAMPBELL AND C. F. POWELL. *Iron Age*, 169, No. 15, 113 117 (1952) Apr. 10.

Dense and uniform coatings of metals, alloys and non-metals can be deposited on one another at temperatures far below their melting points by vapor deposition. Effects of temperature of the coated surface, pressure of the reactants, and impurities in the plating atmosphere on the coating obtained are discussed. Apparatus for continuous coating of wire and for coating inductively heated nozzles is shown. A table shows deposition reaction, deposition temperature, deposition pressure, ductility of coating, and oxidation resistance of coating for a number of metals, carbides, nitrides, borides, silicides, and oxides.—NSA.

5.3.4

Metal Spraying for Protection and for Reclamation. *Electroplating*, 5, No. 3, 101-105 (1952) Mar.

Abstracts from Symposium held by the Institute of Welding. The papers are: 1) "Metal Spraying Technique as Applied to Protection," by W. E. Ballard; 2) "The Use of Metal Spraying for the Protection of Structural Steelwork," by V. E. Stanbridge; 3) "Metal Spraying as a Building-up Process: A Brief Survey of Techniques, Characteristics and Applications," by J. B. Stiles; and 4) "Salvage of Worn Machinery by Metal Spray," by G. A. Onion.

The full text of these papers was published in the February issue of the "Institute of Welding."—BNF.

5.3.4, 1.3

The Metallizing Process. F. KELLER. *Welding Journal*, 31, 291-295 (1952) Apr.

Brief historical review of the metallizing process; its field of application, apparatus needed, methods used in preparation of surfaces, the nature of the coating and some application.—MR.

5.3.4, 3.6.1

Prevention of Corrosion by Metallic Coatings. U. R. EVANS. (Cambridge Univ.) *Research*, (London), 5, No. 5, 220-225 (1952) May.

Outlines the electrochemical principles underlying the method of protecting steel from corrosion by means of metallic coatings. Examples are given of anodic and cathodic coatings. Methods

of application including electro-deposition, hot-dipping in molten metal, spraying with molten metal particles, diffusion, vapor and mechanical processes, and electrochemical behavior of metals in contact are considered. Illustrations and references are given.—INCO.

5.3.4, 5.9.1, 1.6

The Metco Metallizing Handbook. H. S. INGHAM AND A. P. SHEPARD. 250 pages. (1951) Metallizing Engineering Co., Inc., Long Island City, N. Y. Per Copy \$3.00.

Illustrated with diagrams and charts, the book covers technical and practical aspects of the metallizing process. Various methods of surface preparation, and the application of sprayed metals for machine elements, corrosion resistance and many special production jobs are explained. The book is for sale postpaid in the United States and Great Britain only.

5.3.4, 6.3.21

Antimony Plate. ADOLPH BREGMAN. *Metal Progress*, 59, 245-247 (1951) Feb.

Recently improved techniques for plating antimony on steel permit the production of corrosion- and tarnish-resistant coatings that might substitute for platings of more economically critical metals such as nickel and chromium. Antimony platings can be produced preferably from baths containing antimony trifluoride or oxide, ammonium fluoride or ammonium hydrogen fluoride, and ammonium hydroxide, and having a hydroxyl ion concentration slightly less than that necessary to cause precipitation. Coatings 0.001 inch thick can be obtained in less than 30 minutes at customary current densities and at voltages somewhat more than half those required for equivalent nickel deposits. A slight degree of surface roughening by mechanical or chemical pretreatment is necessary.

The resulting coatings readily take a high polish; they have a silvery appearance and a reflectivity higher than that of chromium. In indoor environments, including those of chemical laboratories, the coatings retain their polish indefinitely. The resistance of these coatings to marine environments is equal or superior to that of the best copper-nickel-chromium coatings of equivalent thickness and their resistance to industrial solutions, especially acids, is better than equivalent plates of any other non-precious metal.

The tendency exhibited by antimony deposits on copper to become brittle on aging was not observed in antimony platings on steel which had aged for more than 5 years.

The disadvantages of antimony include the following: Its scratch resistance is poorer than that of iron, nickel, and chromium, although better than that of lead, zinc, tin, cadmium, silver, and copper. Since the protective effect of antimony is not sacrificial in nature, but is based on its own corrosion resistance, continuous, nonporous coatings are required. Antimony cannot be used at temperatures approaching its melting point, 1167° F.

Ease of soldering makes antimony platings especially suitable for electrical and other complicated metal parts. Potential uses include hardware items and radio and radar parts. Unique uses of antimony coatings are those based on the resistance of antimony to mineral acids.—NRC.

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5.3.2, 5.3.4, 6.2.3

Sprayed Aluminum Coats for the Protection of Steel. T. P. HOAR. *Metal Spraying* (England), 2, No. 5, 171-174 (1952) May.

The author reviews the use of sprayed aluminum coatings for the protection of steel under the headings: Comparison of Wire and Power Spraying of Aluminum; Electrochemical Relationships of Aluminum, Zinc and Steel; Composite Aluminum-Zinc Coatings; Sprayed Coats as Basis for Paint; and Modification of Sprayed Aluminum Coatings by Heat Treatment. The author concludes that sprayed aluminum coatings may often replace sprayed zinc, although there are cases where the one or other metal is to be preferred and other cases where composite coatings have considerable promise. The replacement of galvanized coatings with sprayed aluminum is an economic proposition only where extra thick galvanized coatings are concerned; the general run of galvanized coatings is much thinner than that of sprayed. Replacement of sheradized coatings by sprayed aluminum or zinc is not always technically or economically possible—ALL.

5.3.2, 5.4.5, 5.9.4

Phosphate Coatings Versus Galvanizing. R. W. BAILEY. *Product Finishing*, (London) 5, No. 1, 102 (1952) Jan.

A letter drawing attention to misleading statements in a previous article which compared the lives of paint-plus-phosphate coatings with those of very thin zinc plated coatings. The salt spray test is not suitable for comparing the corrosion resistance of different protective systems. Zinc protects exposed steel at scratches and chips sacrificially and, in addition, coatings applied by galvanizing are very resistant to abrasion.—ZDA.

5.3.2, 6.4.2

Aluminum Electroplated on Steel From Fused Salt Bath. F. R. COLLINS. *Iron Age*, 169, 100-101 (1952) Jan. 17.

Aluminum has been successfully electroplated on steel from a fused aluminum chloride-sodium chloride salt bath. The plate is uniform and no interfacial layer of iron-aluminum alloy occurs. Coated steels show high resistance to rusting in industrial, sea-coast, and humid atmospheres. Coating is free of continuous pores. Photomicrographs.—BLR

5.8 Inhibitors and Passivators

5.8.3, 2.3.9

The Use of Radioactive Tracers in the Study of the Mechanism of Action of Corrosion Inhibitors. D. M. BRASHER AND E. R. STOVER. (D.S.I.R. Chemical Research Lab.) *Chemistry & Industry*, No. 8, 171-172 (1952) Feb. 23. See also: *Chemical & Engineering News*, 4477 (1951) Oct. 22.

Work was directed toward the elucidation of the inhibitive action of sodium benzoate but with the excessive cost of sodium benzoate containing C^{14} it was decided to develop the necessary micro-technique by preliminary work with radioactive potassium chromate. The macro-distribution of the radioactivity on the surface was studied by an autoradiographic technique using X-ray film, and Autoradiographic Stripping plates. Preliminary experiments show that chromium, as the ion or as the benzoate

molecule, are present on the surface of the mild steel after immersion and subsequent washing. A detailed interpretation must await further work in progress but the evidence demonstrates that, with both potassium chromate and sodium benzoate, the inhibitor is directly involved in the protective surface film. Graphs and references are included.—INCO.

5.8.3, 4.4.2

The Adsorption of Hydrophobic Monolayers of Carboxylic Acids. HAYWARD R. BAKER, ELAINE G. SHAFRIN, AND WILLIAM A. ZISMAN. *J. Phys. Chem.*, 56, 405-412 (1952) Mar.

The adsorption technique reported previously was successfully extended to the study of monolayers physically adsorbed onto platinum from aqueous solutions of a variety of mono- and dicarboxylic acids. A new "thermal gradient method" for using a pure, molten compound was found by which adsorbed, close-packed monolayers can be prepared and isolated on metal in the absence of solvent. 18 references.—BTR.

5.8.3, 5.9.2

On the Action of the Inhibitors in Pickling. (In Italian.) A. INDELLI AND G. P. BOLOGNESI. *Metallurgia Italiana*, 44, 73-77 (1952) Feb.

After some considerations on pickling and on the action of the inhibitors the authors report the gas-volumetric results of the allile isosulfurcyanate vs. the acid concentration at two different temperatures.

By an electrochemical method the authors then investigate the mechanism of action of the allile isosulfurcyanate vs. the acid concentration. At the end, the authors carry out a few tests to appreciate the efficiency of the pickling inhibitor both as to the economy in iron and acid and to the economy of the anti-corrosive characteristics of the surfaces obtained. 33 references.—MI.

5.8.3, 5.9.2

Use Inhibitors to Help Conserve Pickle Acids. PAUL A. HUPPERT. *Ceram. Ind.*, 58, 61-62 (1952) Feb.

Describes how inhibitors work and discusses their advantages for enamellers, a few of which are metal conservation, smoother metal surfaces at less cost, and elimination of over-pickling.—BLR.

5.8.3, 5.9.4, 6.3.6, 6.3.11

"Immunization" of Metallic Surfaces Against the Action of Corrosive Agents. (In French.) JEAN LOISELEUR. *Compt. rend.*, 234, 260-262 (1952) Jan. 7.

Discusses the formation of a monomolecular layer of Cassius purple on a polished silver or copper plate. This imparts to the plate a remarkable resistance to oxidation and reaction with sulfur. Application to other metals and mechanism of the protective action are discussed. "Immunization" is defended as a suitable term for the particular type of protection.—BTR.

5.8.3, 6.2.2

An Electron Diffraction Study of Films Formed by Sodium Nitrite Solution on Iron. M. COHEN. *J. Phys. Chem.*, 56, 451-453 (1952) Apr. 15.

Concerns the mechanism by which sodium nitrite inhibits corrosion of iron. The passive film formed by sodium nitrite is $\gamma\text{-Fe}_2\text{O}_3$ with a small amount of $\gamma\text{-Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$. The oxide film is

formed by a reaction between nitrite (and O_2) and metal at liquid-metal interface, with adsorption of inhibitor as a probable intermediate step. Tables.—BTR.

5.8.4, 4.6.4, 5.7.1

Prevention of Corrosion in Cooling Water. R. C. ULMER AND J. W. WOOD. A paper presented at a meeting of Western Region, National Association of Corrosion Engineers, Los Angeles, Cal., November 9, 1951. *Corrosion*, 8, No. 12, 402-406 (1952) Dec.

General considerations involved in reducing corrosion by the several types of cooling water systems are discussed. The objective of treatment is to form a coating protective against corrosion but not too thick to seriously affect efficiency of heat exchange surfaces. Treatments include pH control, addition of antibacterials, insulation to stop stray current corrosion, oxygen removal.

Information on laboratory research on inhibitors by the Drew Company is given. Addition of chromates in correct concentrations stopped corrosion but insufficient amounts caused pitting. Silicate-phosphates gave better results. Mechanism of silica-base inhibitors is discussed. Conclusions reached include the controlled calcium carbonate method requires too close control, chromates are effective in proper concentrations but relatively expensive unless small volumes of water are involved. Erratic results were obtained with systems involving complex phosphates at pH 6.0 and chromate-phosphate combinations. Good results were obtained with silicate-phosphate combinations.

5.8.4, 8.4.3

Production-Proved Inhibitor Gets Results in Refineries and Natural-Gasoline Plants. FORREST E. LOVE. *Oil Gas J.*, 50, 310-312 (1952) Mar. 17.

An organic corrosion inhibitor used in refineries to afford protection in practically every kind of refining process and against most types of corrosion encountered by refiners is called Kontrol, manufactured by Tretolite Co. A possible exception is high-temperature, furnace-tube corrosion. Brief summary of different installations where the material is in service.—MR.

5.9 Surface Treatment

5.9.1.

The Preparation of Metallic Surfaces for all Application of Coatings. S. M. ANDERSON. *The Australasian Engineer* (Australia), 44, 68-70 (1952) Jan. 7.

This is the first paper in a symposium on "The Surface Treatment of Metals." This discussion is divided as follows: 1) removal of dirt and soil of an oily nature, 2) the removal of scale oxides, corrosion products, etc., and 3) the production of a satisfactory surface condition of finish.—ALL.

5.9.1

The Mechanical Surface Finishing of Metals. G. T. COLEGATE. *Sheet Metal Ind.*, 29, 71-78, 82, 163-172 (1952) Jan., Feb.

First installment of a series which will consider in detail the various methods used for the above. In the majority of cases, the methods considered will form part of a sequence, the final stage of which is electrodeposition, coloring.

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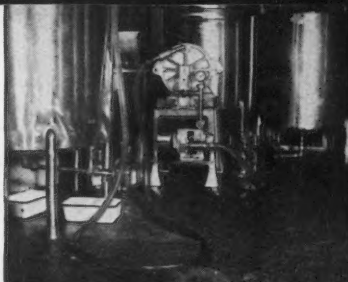
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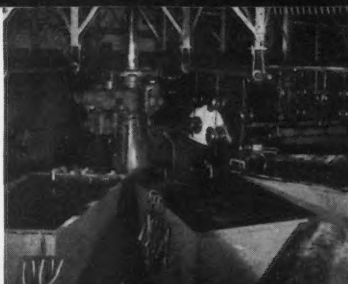
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or some other form of chemical or electrochemical treatment such as anodizing. Polishing is covered in Part 1. Second part covers the effect of various factors on ease of polishing.—BLR.

5.9.1

Improving the Corrosion Resistance of Metal Surfaces. A. L. ALEXANDER. (Nav. Res. Lab.). *Electrical Mfg.*, 49, No. 2, 112-115, 258-268 (1952) Feb.

Even the highest-quality organic finishes require proper preconditioning of surfaces prior to application to guard against degradation. Currently used materials and techniques and research developments designed to extend the useful life of both the finishes and the metals are discussed. White surface, commercial surface, and brush-off surface finishes on flat work of new steel are considered. Preparation of anodic films on aluminum and its alloys followed by different organic coats increase protection against corrosion. Wash primer treatment makes possible good adhesion of metallic surfaces hard to coat, such as galvanized iron and stainless steel. The inhibition of rust is accomplished by converting the surface of iron metals into insoluble phosphate salts which appears to increase wear resistance of iron and steel parts. Specific applications are given. Photographs and 11 references.—INCO.

5.9.1, 5.4.7

How Navy in Seattle Refinishes Salt Water Pitted Propellers. HOWARD E. JACKSON. *Western Metals*, 10, 49-50 (1952) April.

Series of steps involved include mechanical and chemical cleaning, anodizing, spray painting, etc.—MR.

5.9.2

Corrosion by Retained Treatment Chemicals on Phosphated Steel Surfaces. S. G. CLARKE AND E. E. LONGHURST. *J. Iron Steel Inst.*, 170, 15-18 (1952) Jan.

Results of humid-atmosphere corrosion tests are presented. A simple performance test is suggested as a guide if the corrosive tendency of a phosphating solution is not known, or if the geometry of the parts treated makes effective washing difficult.—BTR.

5.9.2, 5.8.3

Pickling and Pickling Acid Inhibitors: Functions, Behavior and Applications. A. DOUTY. *Metal Ind.*, 80, No. 6, 108-110 (1952) Feb. 8.

The author, after describing the action of acid pickling solutions, considers the desirability of inhibitors. Five classes of organic inhibitors are listed, the mechanism of their action discussed, and methods of measuring the degree of inhibition described. A section of the article is devoted to a discussion of hydrogen embrittlement. In conclusion, three relatively new methods for oxide removal from steel are mentioned: a fused bath of caustic soda containing sodium hydride at a temperature of 370° C; treatment of hot steel with flue gas and chlorine; treatment of hot steel with certain salt mixtures.—ZDA.

5.9.2, 6.2.2, 5.8.2

A Study of Acid Pickling Solutions for Wrought Iron and Steel with Special Reference to the Use of Inhibitors. E. E. HALLS. *Electroplating*, 5, No. 5, No. 5, 143-150 (1952) May.

Hydrochloric acid or sulfuric acid are

used to pickle iron and steel components which develop rust and scale. Two ways of overcoming difficulties involved in immersion time and graphs covering the dependence of pickling time on temperature and acid concentration are considered. Cold rolled close annealed mild steel was used to represent lightly sealed work and hot rolled black steel section for the extreme case. The effect of pickling inhibitors on bright annealed and black cold rolled close annealed steels in hydrochloric acid and in sulfuric acid are tabulated and discussed. The inhibitors affect film formation and increase of hydrogen over-voltage. They are soluble in acid, stable and able to retain their beneficial effect on prolonged storage. They are essential to conserve acid and to reduce unnecessary attack on the metal.—INCO.

5.9.2, 6.4.4

How Alkaline Cleaners Affect Magnesium Die Castings. A. G. GRAY. *Products Finishing*, 16, No. 8, 62+ (1952) May.

In tests on magnesium alloy AZ 91 (magnesium-aluminum-zinc), sodium hydroxide, trisodium orthophosphate, tetrasodium pyrophosphate, crushed Calgon, Quadrafos and several sodium silicates were used as cleaners. A table summarizes the weight changes of magnesium alloy in various aqueous solutions and a second table gives the weight losses of magnesium alloy following anodic and cathodic treatment in alkaline cleaning solutions. Alkaline cleaners having a pH above 11 give best results with magnesium. Acid cleaning of magnesium involves a pickling treatment to remove surface contamination. This must be done immediately prior to the application of final finishing chemical treatments, the type of pickling depending on the contamination to be removed. Several recommendations are made as to alkaline cleaners, acid cleaners and pickling baths.—ALL.

5.9.2, 7.6.4

Phosphoric-Acid Cleaning of Boilers. T. E. PURCELL AND S. F. WHIRL. *Trans. Am. Soc. Mech. Engrs.*, 73, 135-139 (1951) Feb.

Because of the limitations and adverse effects of hydrochloric acid, the possibility of using phosphoric acid for boiler cleaning was investigated. Inhibited phosphoric acid is a good solvent without the unfavorable properties and characteristics of inhibited hydrochloric acid. This material has been used successfully for removing rust and mill scale from a new boiler.—MR.

5.9.4, 1.2.4

Protective Finishes . . . Phosphate Coatings for Military Equipment. Part I. Finishes and Undercoating. Part II. Rust Proofing and Protecting Friction Surface. N. F. GENTIEU. *Am. Chem. Paint Co. Product Engineering*, 23, No. 2, 183-190 (1952) Feb.; *Machine Design*, 24, No. 1 and 2, 108-114+, 141-145+ (1952) Jan., Feb.

Review of the types of phosphate coatings being specified by the armed services for protection of metal surfaces. These coatings are formed by dipping the work into coating baths, carrying it through several sprays, or applying the coating solutions with a brush. Government specifications for various finishes are given in table form with preparations for steel, iron, zinc, cadmium, and aluminum surfaces. During World War

II, most of the small arms were finished with a zinc-base phosphate which more recently has been changed to the manganese-phosphate finish because it was found to stand up better under the abuse of field handling. Rustproofing and protection for friction surfaces with phosphate coatings are discussed. Illustrations, tables are included.—INCO.

5.9.4, 1.3

Electrochemical and Chemical Coatings for Aluminium. A. G. GRAY. *Products Finishing*, 16, No. 4, 46-60 (1952) Jan.

This is a review article on anodizing and chemically coating aluminum. The oxide coating formed by anodizing offers protection against scuffing and eliminates smudging. The corrosion protection afforded by the coating depends upon its continuity. The effective continuity of the coating increases with the thickness, up to certain limits. The sealing treatment in the anodizing of aluminum closes the pores of the coatings and makes it non-adsorptive and stainproof. The type and pH of the water used in sealing has been found to affect the life of the coating according to tests conducted by A. E. Durkin. The production of oxide and phosphate coatings on aluminum is described. Tables are included listing procedures for anodizing aluminum, and the results of salt spray and atmospheric exposure tests of anodically coated aluminum panels.—ALL.

5.9.4, 2.3.2

Phosphate Coatings. A. C. HANSON. *Metal Progress*, 61, No. 2, 81 (1952) Feb.

The Rock Island Arsenal Laboratory has devised a quick test to verify the quality of phosphate coatings. Specimens of the phosphated work are covered with water saturated with oxygen and boiled for 15 minutes. They are then rinsed with cold water and tested for rust with a photographic imbibition paper pre-soaked in water for 15 minutes. The paper is squeezed onto the surface of the specimen and allowed to remain in contact for 3 minutes. It is then examined for rust. Any rust indication constitutes rejection and further confirmatory tests must be made. A second failure obtained on twice the number of test specimens constitutes a final rejection of the lot of work being tested.—INCO.

5.9.4, 2.3.4

Phosphate Coatings as a Basis for Painting Steel. British Standards Institution, Phosphate Coatings (Drafting) Panel. *J. Iron Steel Inst.*, 170, No. 1, 10-15 (1952) Jan.

An account is given of the results obtained when analytical and performance tests were applied to industrial phosphate coatings. The addition of small amounts (about 0.1%) of chromic acid to the water used for rinsing after phosphating was found to improve the protective properties of the coating, but high concentrations (> approx. 0.5%) were injurious because the coating was dissolved.—BNF.

5.9.4, 3.2.3, 3.8.2

Some Factors in Anodic Processes on Corroding Metals. T. P. HOAR AND U. R. EVANS. Cambridge Univ. Paper before Electrochemical Society, Washington Mtg., April 8-12, 1951. *J. Electrochem. Soc.*, 99, No. 5, 212-218 (1952) May.

Many alloying elements that confer resistance to high-temperature oxidation also prevent low-temperature aqueous



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corrosion; they produce oxide films that only slowly transmit cations. Conversely sulfur, which introduces lattice defects into the films and thus favors the transmission, accelerates high-temperature oxidation and favors the onset of aqueous corrosion. The onset of aqueous corrosion is controlled by the relative ease with which cations can pass through the original air-formed oxide film on the metal. A rapid supply of dissolved oxygen to all parts of the surface may arrest cations as they emerge. Further development of the anodic zones depends on the production of anodic acidity. 46 references.—INCO.

5.9.4, 3.5.3, 3.5.8

Minimizing Friction and Wear F. T. BARWELL. *Machine Design*, 24, No. 4, 300, 302, 304, 306, 308 (1952) April.

Phosphating method to prevent metallic contact, and use of copious supplies of lubricant to remove debris and to minimize the supply of oxygen to any naked metal which may be exposed by penetration of the thick phosphate layer are discussed. The various forms of wear including seizing, scuffing and fretting corrosion are mentioned.—INCO.

5.9.4, 4.4.8, 5.4.9, 7.1

Special Dip Routine Bans Weekend Rust. *American Machinist*, 96, p. 143, (1952) Feb.

How surfaces of steel gears, shafts, and other parts are protected against corrosion for up to two months in 95 percent humidity conditions at Boston Gear Works. A water solution of a nitrite chemical called "VPI," and made by Shell, proved to be the answer to the problem.—MR.

5.9.4, 5.3.4, 2.3.2, 2.2.5

Phosphate Coating v. Galvanizing. JOHN H. LAWRENCE. *Machinery Lloyd (Overseas Ed.)*, 24, 105-106 (1952) Feb. 16.

Discusses comparative values for the above obtained by salt-spray and actual weathering tests. Impact and distortion tests were also made. Graph presents corrosion-resistance data.—MR.

5.9.4, 6.2.3, 7.1, 4.2.7

Corrosion Proofing of Steel Parts. *Engineers' Digest*, 13, No. 1, 3-4 (1952) Jan.

Resistance of machine components of steel to atmospheric corrosion, especially in tropical climates, while kept in storage prior to assembly, is improved by steam blueing the surface. The latest process employed for steam blueing consists of a steam treatment of 920° F.—INCO.

5.9.4, 6.4.1

Prevention of Corrosion by Pretreatment on Light Metals. C. AIDA AND S. ONISHI. *Light Metals (Japan)*, No. 3, 47-52 (1952) May.

The improvement of pretreatment for painting on light metals is the subject of corrosion prevention in ship construction. The electrolytic polishing, Alumite, M. B. V. or B. V. methods are superior in anticorrosion to ordinary phosphate-alcohol method, but these methods cannot easily be applied on the large plate as ship construction in view of the capacity of electric source or the equipment for heating.

Through the study of the corrosion test in salt solution, a new modified phosphate-alcohol method has been developed. This method can be applied by

either brushing or immersion, the concentration of phosphate being 25% for immersion. In both brushing and immersion methods it is not necessary to heat the solution. In each process, water can be used instead of alcohol. After this treatment, the metal surface can be immediately painted without water rinse.

The phosphate and chromate method or sodium phosphate and chromate treatment also exert a good influence on the light metals at room temperature. Corrosion resistance by these methods is equal to that by the albond method.

These new methods can be applied almost equally on 2S, 61S, 52S, and 56S plate. Paint film following these treatments adhere to the metal surface and can endure a long time against weathering tests.—JSPS.

5.11 Design-Influence on Corrosion

5.11, 3.1, 4.1

(1) **Corrosion Factors in Design.** (2) **Recommended Design Details to Reduce Corrosion.** F. M. REINHART. *Product Eng.*, 22, No. 7, 101-107; 158-159 (1951) July.

Factors contributing to corrosion and methods of minimizing the attack for atmospheric, under-water galvanic, concentration-cell, stress and fretting corrosion. Of general interest, although examples involving specific metals are given.—BNF.

5.11, 1.2.2

Designing for Corrosive Services. F. A. PRANGE. Engineering Department, Phillips Petroleum Company, Bartlesville, Oklahoma. A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., October 1-3, 1952. *Corrosion*, 9, No. 1, 35-37 (1953) Jan.

This paper discusses in general fashion the problems of designing for corrosive processes. Good design data, which is obtainable from the pilot plant data will insure more reliable operation of the full scale plant. Shutdown procedures and equipment inspection methods should be considered in the designs. In the choice of materials due consideration should be given to ease of fabrication and ability to withstand abuse. Failure analysis of the pilot plant and full scale equipment can do much to improve reliability and to reduce cost of construction.

6. MATERIALS OF CONSTRUCTION

6.1 General

6.1, 1.6, 1.5

Korrosionstabellen Metallischer Werkstoffe. By FRANZ RITTER. (In German.) 283 pages, 6½ x 8½ inches. Cloth. (1952) Springer-Verlag, Molkerbastei 5, Vienna, Austria. Per Copy, \$8.20.

Principal content of this book useful to the corrosion worker is 209 pages of tables in which the corrosion resistance of materials is related to alphabetically arranged corrosive agents. Data are given in weight losses of grams per square meter per day and in penetration values of millimeters per year. The data tabulated are derived from 991 literature references which are listed in a reference section.

The book includes a materials catalog in which the German, U. S. and British names of metals are tabulated against their analysis. The catalog covers metals from aluminum through zinc and precious metals.

Supplementary tables covering 18 pages give recent data on attacks by corrosives.

6.2 Ferrous Metals and Alloys

6.2.1, 8.1.2, 8.9.4

Iron and Steel Structures. J. L. BECKEL. *Am. Ry. Eng. Assoc. Bull.*, 53, 507-609 (1952) Jan.

A committee report including design of expansion joints involving iron and steel structures; stress distribution in bridge frames; design of steel-bridge details; preparation and painting of steel surfaces; use of high-strength structural bolts in steel railway bridges; and means of conserving labor and materials, including adaptation of substitute non-critical materials, and specifications for reclamation of released materials, tools and equipment.—BLR.

6.2.2, 3.4.6, 3.5.9

Diffusion of Hydrogen in Iron and Iron Alloys at Elevated Temperatures. P. L. CHANG AND W. D. G. BENNETT. *J. Iron Steel Inst.*, 170, Pt. 3, 205-213 (1952) Mar.

Effects of chromium, nickel, and molybdenum on the rate of hydrogen permeation in iron were investigated. Chromium has little effect on permeation in the γ range but greatly reduces the rate of permeation in the α range. Nickel and molybdenum have little effect. The materials studied were an ingot iron and a series of iron-chromium, iron-nickel and iron-molybdenum alloys with up to 10 percent alloying element. A permeation equation is given. Diagrams, graphs, tables and 19 references are included.—INCO.

6.2.2, 3.5.9, 2.1.2

Tests on Heat-Resisting Cast Irons. M. M. HALLET. *J. Iron Steel Inst.*, 170, 321-329 (1952) Apr.

Provides data for all usual heat-resisting cast irons, for selection of most suitable material for given conditions. Includes studies on resistance to scaling, and failure by cracking. Tables, graphs, and micrographs.—BLR.

6.2.2, 3.7.2

Strong Newcomer. *Amsco Bull.*, No. 1, 8-9, 1952.

Cast iron that stretches, bends, and twists without failure—that's Ductalloy, now being produced by American Brake Shoe Company. Ductalloy is Brake Shoe's trade name for ductile iron. The difference between gray cast iron and Ductalloy starts at the ladle, when a quantity of magnesium is added to the melt. In order to make the inoculation more effective and less spectacular, the magnesium is usually alloyed with nickel. The properties of Ductalloy and list of conditions justifying application of Ductalloy are discussed. At present 3 grades of ductile iron are being produced. Two grades are those for which tentative specifications have been drafted by ASTM—specifications based on physical properties rather than chemical analysis. The third is an austenitic grade with characteristics suiting certain aircraft applications.—INCO.

6.2.2, 3.7.4

Spheroidal-Graphite Iron Up to Date. W. W. BRAIDWOOD. Paper before Inst. Brit. Foundrymen, Scottish Branch. *Foundry Trade J.*, 92, Nos. 1856, 1857, 1858; 323-329, 361-366, 393-394 (1952) Mar. 27, April 3, April 10.

Attempt to survey the progress of the development of spheroidal-graphite iron to date, to assess the position now reached, and to forecast its future. The nomenclature, patents, specifications, applications, heat-treatment, hardness, machinability, resistance to high temperature and other properties are discussed. Introduction of magnesium and the basic cupola are covered. Photomicrographs, illustrations and 31 references are included.—INCO.

6.2.2, 3.7.4, 3.7.2

Nodular Graphite in Cast Iron. A. I. KRYNITSKY AND H. STERN. National Bureau of Standards. *Foundry*, 80, Nos. 3 and 4; 106-111+, 98-99+ (1952) Mar., April. See also: New Data on Ductile Cast Iron. *Tech. News Bull.* (Nat. Bur. Standards), 36, No. 4, 49-50 (1952) Apr.

Study of the effect of treatment with magnesium, magnesite, iron sulphide, calcium, nickel, chromium, molybdenum, and boron on the graphite structure of cast iron. Completely nodular graphite was produced only in iron containing more than 0.03 magnesium. Two types of nodules were observed—radial and structureless. Rapid cooling facilitated nodule formation but the effect of cooling rate decreased with increase in magnesium content. No relation between the nodule formation and pouring temperature or maximum heating temperature was observed. This study supports the belief that nodular graphite is formed in the melt during solidification, and graphite patches are produced after solidification by decomposition of carbides. Tables, photomicrographs and 17 references are included.—INCO.

6.2.2, 4.3.2, 3.7.2

Study on the Acid Resisting High Silicon Iron. A. ANDO AND T. ISHINO. *Sulphuric Acid*, 5, No. 4, 128-135 (1952) April.

High silicon cast iron is a very useful acid resistant material, but its machinability and mechanical strength are not too satisfactory.

This report refers to the effect of variation of silicon, carbon and other elements (nickel, chromium, molybdenum, boron, magnesium, etc.) and machinability, mechanical strength and acid resistivity.

The results were as follows: 1) 5-6% of silicon alloy has a good quality against cutting and mechanical strength. 2) The range of good machinability is within 13% silicon. 3) Over 12% silicon alloy is better in acid resistivity and 14% silicon is the best. 4) 5% silicon alloy containing copper has great resistivity to hydrochloric acid but not so good to sulfuric acid. 5) 14% silicon alloy containing boron or magnesium has good machinability.—JSPS.

6.2.2, 4.7, 3.4.6

Corrosion of Cast Iron By Molten Zinc, With or Without Prior Oxidation. (In French.) P. BASTIEN AND P. AZOU. *Fonderie*, No. 74, 2831-2845 (1952) Mar.

Study of the corrosion by molten zinc at 650° C. of grey and malleable iron, of four alloy cast irons and of mild steel; a) not oxidized, and b) oxidized by heating for 8 hr. at 850° C. in air. Grey cast

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iron showed best resistance. Oxidation gives some protection but, is under certain conditions, harmful in itself.—BNF.

6.2.2, 5.11

Process and Product Advantages of Gray Cast Iron. C. O. BURGESS. *Am. Foundryman*, 21, No. 3, 60-64 (1952) Mar. Describes the metal casting process on the basis of improved operational or functional quality of product, and economic advantages as a manufacturing method. Savings come from the ability to combine a number of individual parts into a single casting, casting design freedom that reduces machining and metal wastage, low cost of patterns, and production of flexibility at low cost. Table and illustrations are included. Fourteen references.—INCO.

6.2.2, 8.10.2

America Outstripped in Malleable Iron. F. D. LEY. *Foundry Trade J.*, 92, No. 1854A (Golden Jubilee Number), 73-80 (1952) Mar. 15.

Fifty years ago, it was reported that the British malleable castings industry was lagging behind its American counterpart, yet today it is well to the fore. The steps by which this worthwhile advance has been achieved are reported in this article.—INCO.

6.2.4, 2.2.2, 5.4.5

Protection Against Corrosion and Use of Low-Alloy Steels. (In French.) D. BERMANE. *L'Ossature Metallique*, 17, 42-48 (1952) Jan.

Presents results atmospheric tests on uncoated and paint-coated steels of various compositions. Includes tables, diagrams, charts, and photographs. 15 references.—BTR.

6.2.4, 2.3.7

Notch Sensitivity at High Temperatures Evaluated. W. F. BROWN (NACA) AND G. SACHS (Horizons, Inc.). *Iron Age*, 169, No. 12, 91-95 (1952) March 20.

A National Advertising Committee on Aeronautics survey shows that at short times to rupture, strength of notched low alloy bolting and boiler steels at 932° F exceeds that of unnotched bars. The amount depends primarily on depth of notch. With increasing time to rupture, notched strength falls well below unnotched specimens—until 30,000 hours is reached, when notched bars may recover. Low original ductility means low notch strength. Heat treating to raise creep strength increases notch sensitivity. In nickel-free annealed boiler steels the strength of the notched with increases in rupture times may gradually approach and eventually be the same as the unnotched strength. The strength of the notched bar of chromium-nickel-molybdenum steel decreases rapidly with increasing time to rupture and falls well below the strength of the unnotched specimen. 13 references.—INCO.

6.2.5, 3.2.2

Resistance to Intergranular Corrosion of Ferritic and Martensitic Stainless Chromium Steels. E. HOUDREMONT AND W. TOFAUTE. VDE Committee for Materials Report No. 784. *Stahl u. Eisen*, 72, No. 10, 539-545 (1952) May 8.

Investigation of 15-30 chromium stainless steels with or without additions of molybdenum, aluminum, silver, phosphorus, titanium, tantalum, niobium, and vanadium regarding their tendency to intergranular corrosion, their hardness and structure. Carbide precipitation as

a cause of intergranular corrosion and modification of the theory of chromium impoverishment are included. 11 references.—INCO.

6.2.5, 3.7.2

Stainless and Acid Resistant Steels in Chemical Engineering. H. BRAUN. *Werkstoffe u. Korrosion*, 3, No. 3, 93-98 (1952) March.

Not enough attention is given to the suitable selection of stainless and acid-resistant steels such as 18-8 in chemical engineering. The high alloyed steel is not always the most suitable one. There is a large range of uses for 17 chromium steels, free of nickel. Directions for conserving materials are given. The different behavior of some single alloyed refined steels is illustrated by resistance curves. Corrosion and means of preventing it are discussed.—INCO.

6.2.4, 3.7.2, 3.7.4

Boron Steel Development. D. L. MCBRIDE (Nat. Res. Council). Paper before SAE Iron & Steel Tech. Comm., Div. VIII, Detroit, Dec. 4, 1951. *SAE Journal*, 60, No. 3, 26-34 (1952) Mar.

Review of information on boron steels includes the properties of boron steels, the effect of boron on the notch toughness and embrittlement. Boron increases hardenability, but the weldability, carburizing behavior, machinability, annealing and tempering behaviors of the boron steels do not seem to be affected by the presence of boron. Boron steels, of intermediate or high carbon, distort on liquid quenching in exactly the same manner as steels of equal hardenability, without boron. Some typical boron steels and their compositions (nickel ranging from 0.01-1.83) are given in table form. Tables and graphs are included.—INCO.

6.2.5, 4.3.1

Stainless Steels in Chemical Handling. *Can. Chem. Processing*, 36, No. 2, 64 (1952) Feb.

For pumping ammonium sulfate solution under high head, 2-stage pumps are constructed of Type 316 stainless steel. For acid pumps a cast stainless steel containing nickel, chromium, molybdenum, and copper has many advantages. In the ammonia plant, high pressure forgings for the ammonia synthesis converters are made from 3130 type chromium-nickel stainless steel, containing also molybdenum and niobium. Ammonia and sulfuric acid react together in the sulphate plant, where the ammonium sulfate solution produced is pumped by Type 316. Type 347 (chromium-nickel-niobium) stainless steel is used almost exclusively in the nitric acid and ammonium nitrate plants for handling 56 percent nitric acid in converters, absorbers, boilers, condensers, etc. Cominco utilizes principally 3 grades of stainless steel, namely Types 316, 318, and 347.—INCO.

6.2.5, 7.6.1, 5.11

Modern Trends in Process Equipment Design. *Can. Chem. Processing*, 36, No. 1, 54-56 (1952) Jan.

There have been many changes in the mechanical design and construction materials in chemical processing equipment. Stainless steel equipment, which is easily cleaned is the trend in milk evaporators. The trend for mixing kettles is corrosion resistant, of stainless agitator equipment driven by its own electric motor. A corrosion resistant or stainless steel steam jacketed kettle of all welded construction, sanitary on the

inside, and equipped with automatic temperature control is used. In yeast fermenters, tinned copper is replaced by stainless steel which is more permanent. In distillation and solvent recovery equipment, stainless steel is used because distillation products of alcohol are corrosive on copper. Tanks for storage and heating of water were made of mild steel which is corrosive. Coating steel with zinc galvanizing reduces corrosion but is not completely effective. Between 140° and 160° F and under other conditions, zinc does not protect the steel. Magnesium anodes and glass lining of steel are used but to a great extent those tanks are being made of copper or nickel-copper alloys to eliminate rusting of steel tanks. In brewing, grain is mixed in a mixing tank or "mash tub" with hot water, converted to soluble sugars, and then strained through a sieve in the bottom of the tubs. Formerly made of wood, then riveted steel and later welded steel, the tub shells are now made of stainless steel which reduces cleaning time and increases the life of the equipment. Stainless steel is now used for the false bottoms of the mixing tanks. Photographs are included.—INCO.

6.3 Non-Ferrous Metals and Alloys—Heavy

6.3.10, 3.7.2, 7.1

Nickel-Chromium-Titanium Alloys of Nimonic 80 Type. L. B. PFEIL, N. P. ALLEN AND C. G. CONWAY. Paper before Iron & Steel Institute, London, Feb. 21 and 22, 1951. Symposium on High-Temperature Steels and Alloys for Gas Turbines, Feb. 1951, 37-45. *Metallurgia*, 43, No. 257, 119-126 (1951) March. *Metal Progress*, 59, No. 5, 653-656 (1951) May.

A review of the information on nickel-chromium base alloys is given. The nickel-chromium-titanium series seems to be the most promising group of alloys for high temperature stresses in gas turbines. An account is given of research methods used to determine the solid solubility of selected addition agents, the response of 80 nickel-20 chromium alloys with varying additions of titanium and aluminum to heat treatment, their forgeability, and their high-temperature properties. The properties and characteristics of Nimonic 80 are given. For higher temperature gas turbines, Nimonic 80A (18-21 chromium, 2-2.5 titanium, 1.25 aluminum, bal nickel) has been developed. The minimum properties of Nimonic 80A, as prescribed by DTD specification 736, has a secondary creep rate not exceeding 0.01%/hour, a time- to tertiary-creep of less than 50 hours and a time-to-rupture of not less than 75 hr. under a stress of 17 tons-sq. in. at 750° C. Nimonic alloys have been used extensively in the British airplane engine because of the reliability of production batches to give the high properties specified. Mr. S. T. Harrison stressed the importance of keeping temperatures below specified limits because the properties of the Nimonic alloys drop considerably when the boundary of a single phase region was reached. The only abuse the alloys would not take was considerable plastic strain. Charts. 24 References.—INCO.

6.3.10, 4.3.2

Corrosion: Corrosion of High Ni-Mo

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Alloy by Sulfuric Acid. MARS G. FONTANA. *Ind. and Eng. Chem.*, **44**, 91A-92A, 94A (1952) Jan.

Fifth of a series summarizing corrosion data in chart form. Presents concentrations and temperatures for corrosion of high Ni-Mo alloy by H_2SO_4 .—BLR.

6.3.10, 5.4.5, 3.5.9

Enamel Coatings. P. E. CAVANAGH. *Metal Progress*, **61**, No. 2, 83-84 (1952) Feb.

Saggers made of 15 chromium-35 nickel alloy or of Inconel give excellent performance and good heat transfer in sponge iron and controlled density steel processes. Ferro-Enamel's Xs-169G was applied to the unprepared surface of saggers with a paint brush and passed through a kiln loaded on the normal process cycle of 15 hours at 2200° F. The enamel gave good protection to the metal. Inconel and 15 chromium-35 nickel saggers are now used at 2200° F for 15 hours. The total cycle is 72 hours and the saggers are re-enamelled and immediately recycled. This practice, though the worst method of applying a protective coating, is worth while in saving expensive alloy.—INCO.

6.3.10, 8.8.1, 8.8.6

Corrosion-Resisting Nickel Alloys and Chemical Progress. W. Z. FRIEND AND F. L. LAQUE. (INCO). Paper before ACS, Symp. On "Developments in Nickel," Diamond Jubilee Mtg., 3-7 (1951) Sept. *Ind. and Eng. Chem.*, **44**, No. 5, 965-971 (1952) May.

Summary of the corrosion-resisting characteristics of nickel and high-nickel alloys such as Monel, Duranickel, Inconel, the Hastelloys, Chlorimet, Duro D-10, Illium, the copper-nickel alloys, austenitic chromium-nickel stainless steels, the Ni-Resist alloys and nickel alloy steels. Examples are given of specific applications of these alloys in the manufacture of a number of chemical products, synthetic textiles, dyestuff manufacture, synthetic plastics, antibiotics, fatty acid products and corn products. 84 references.—INCO.

6.3.15, 3.4.6, 3.5.9

Role Played by Nitrogen in High-Temperature Oxidation of Titanium in Air. V. I. ARKHAROV AND G. P. LUCHKIN. *Doklady Akad. Nauk SSSR*, **83**, No. 6, 837-839 (1952).

Experimental study of mechanism of high-temperature oxidation of titanium metal and titanium-iron alloys. Exponential law governing the acceleration of oxidation of titanium metal between 1300 and 2200° F in an oxygen atmosphere vs. air. Results of X-ray study of phase composition of scale found on titanium metal in oxygen vs. air. Data on lattice constants. Change of rutile lattice if nitrogen is present in the atmosphere in which titanium is oxidized. Form in which nitrogen enters the rutile lattice and effect of its entry upon average column of unit cell of lattice. Gradient of lattice constants of rutile as function of depth of scale formed during oxidation of titanium in air, and conclusions to be drawn. Analogous observations on titanium-iron alloys. Translation available from Henry Bratcher, Technical Translations, P. O. Box 157, Altadena, California.

6.3.15, 4.3.2, 5.8.3, 2.3.5

Resistance of Titanium to Sulfuric and Hydrochloric Acids Inhibited by Ferric

and Cupric Ions. Technical Report No. 6. JOSEPH R. COBB AND HERBERT H. UHLIG. Corrosion Lab., Mass. Inst. of Tech. June 1951. 9 p.; *J. Electrochem. Soc.*, **99**, 13-15 (1952) Jan.

Ferric and cupric ions are effective inhibitors for the corrosion of titanium in boiling 10 percent sulfuric and boiling 10 percent hydrochloric acids. As little as 0.005 mole of trivalent iron or divalent copper per liter reduces the corrosion rate from intolerably high values to those typical of Class A materials. The corrosion rates range from 0.001 to 0.012 in./yr. for inhibitor concentrations from 0.03 to 0.005 mole/liter. Although the inhibitors are consumed as titanium corrodes, the consumption is moderate, particularly at the higher inhibitor concentrations for which corrosion rates are lower. The primary mechanism, as indicated by potential measurements, is proposed as occurring through adsorption of trivalent iron and divalent copper on the metal surface with accompanying satisfaction of surface valences and formation of a dipole layer with negative charge outward accounting for a noble potential. (Author.)—NSA.

6.3.15, 5.3.4

Development of Protective Coating for Titanium and Titanium Alloys; Interim Technical Report No. 2, October 1, 1951—January 31, 1952. WILLIAM H. COLNER, MORRIS FEINLEIB AND HOWARD T. FRANCIS. Armour Research Foundation. (nd) 11 p. (NP-3688; Interim Technical Report No. 2; U21434).

The method developed for obtaining adherent copper coatings on titanium by electrodeposition utilizes a zinc strike (at 3 to 4 min and a current density of 36 amp/ft²) from a bath containing hydrofluoric and ethylene glycol before the copper plating. Fairly consistent 0.0005-in.-thick plates were obtained; 0.005-in. plates were not as adherent. Time and current density of the strike bath affected the quality of the coating. Freshly prepared baths often gave more adherent electroplates. Nonadherent plates were obtained with baths based on dioxane or consisting of zinc oxide in HBF₄ (with or without hydrofluoric acid), highly alkaline zinc oxide solutions, or a solution of zinc chloride in concentrated sulfuric acid and 60 percent hydrofluoric acid (NRS abst.)—NSA.

6.3.8, 5.4.5, 1.6

Lead in Modern Industry. The Lead Industries Association. 420 Lexington Avenue, New York, N. Y. 230 pages, 6x9 inches, cloth. (1952). Per copy, \$1.50.

While the book is written in laymen's terms, it also includes technical data and methods which are useful to the engineer. There is a short history of lead from 3000 BC specimens to the present. A description of processes and mining from the raw ore to the finished product or end use is given. The concentration of lead ore, mostly in the form of lead sulfide and smelting lead ore concentrates and the refining process are explained. The most widely used refining process according to the book is the Parkes process.

Secondary lead and world consumption of lead is discussed. A chapter is devoted to the importance of lead in modern living. Lead is used in fertilizer. It is used by scientists experimenting and working with X-rays and gamma rays. Artists use lead in making such things as beautiful glass art objects.

For the technically minded, the book delves into the fabrication, extrusion, rolling various types of castings of lead. Three chapters devote considerable space to the use of lead in storage batteries, cable covers and modern chemical construction. Corrosion resistance of lead and lead alloys, corrosion rate interpretation, fatigue and stress corrosion, galvanic corrosion and like subjects are discussed. The uses of lead in soldering and welding are explained and the composition of commercial pig lead is tabulated.

Several chapters are devoted to the use of lead in protective coatings such as metallic coatings, lead pigmented paints and other chemical compounds for industrial use. Lead for ammunition both in war and peace times is discussed and the use of lead tetraethyl in gasoline is listed as are some of the more important uses of the metal. Considerable space is devoted to the safe handling of lead and its products and many charts and data tables concerning the specifications and properties both physical and chemical for both lead and lead alloys are stated. The book is well illustrated.

6.3.9, 3.5.9

Molybdenum, Our Most Promising Refractory Metal. J. J. HARWOOD. Office of Naval Research. *Product Engineering*, **23**, No. 1, 121-132 (1952) Jan.

Mining and production methods, physical and mechanical properties, high temperature properties, oxidation and corrosion resistance (including a table of molybdenum reaction with different corrosive medium), fabrication and processing, welding characteristics, alloys of molybdenum and applications, are discussed. 14 references.—INCO.

6.4 Non-Ferrous Metals and Alloys—Light

6.4.2, 3.4.7, 3.4.9, 6.6.11

Corrosion of Aluminum by Wood. *Chem. Age (England)*, **66**, No. 1707, 473 (1952) Mar. 29.

Few if any woods induce specific chemical attack on aluminum, but in the moist condition all woods assume the properties of electrolytes. The pH of wood varies from 3.0 to 10.0 according to the species. Aluminum and some alloys corrode at a minimum with a pH between 5.0 and 7.0. The risk of corrosion with wood occurs when the moisture content of the wood exceeds 18 to 20 percent. For composite wood-aluminum structures, one of the factors governing the selection of the woods is the pH which that wood engenders when wet.—ALL.

6.4.2, 4.1

Aluminum. R. L. HORST. Alcoa. *Chem. Eng.* (Part 1), **59**, No. 5, 300+ (1952) May.

Corrosion resistance of aluminum and its alloys to over a hundred common corrosives, including acids, salts, gases and organic compounds is given in chart form. Data on applications, composition and mechanical properties are included.—INCO.

6.4.2, 7.5.5

Aluminum Alloys for Corrosion-Resistant Storage Tanks. E. C. HARTMANN (Aluminum Co. of Am.) AND F. L. PLUMMER (Hammond Iron Works). Paper before ASCE, Structural Div., Houston.

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Civil Engineering, 22, No. 2, 25-27 (1952) Feb.

Aluminum alloys are highly resistant to corrosion when exposed to many liquids and their ability to be worked by commonly used fabricating practices, have led to their adoption as the preferred metal for many types of storage vessels. The three alloys of special interest are 3S, 63S, and 61S. A number of welding methods are used with these materials including gas welding, and the inert-gas metal-arc-method. Tables giving typical mechanical properties are included.—INCO.

6.4.2, 8.9.1

Flight Out of the Test Tube. *Can. Chem. Processing*, 36, No. 4, 46-47 (1952) Apr.

Discussion of the part played by chemical research in the development of modern flight. Aluminum is used for modern aircraft since it is light and has high anti-corrosive qualities. Adding magnesium and silicon help to prevent corrosion but the alloy needs further protection. Alclad, a high-strength alloy coated with a thin covering of relatively pure aluminum was developed for constructing the skin and other parts. Anodizing defeats electro-chemical corrosion by electrolysis. Tests conducted in aircraft producer's laboratories on alloys and metals are given. Photographs.—INCO.

6.4.2, 8.9.5

Aluminum as a Shipbuilding Material. E. C. B. CORLETT, *Trans. N.E. Coast. Inst. Eng. Ship.*, 68, No. 5, 221-248 (1952) Mar.; Abridged versions in *Engineering*, 193, 413-414 (1952) Mar. 28; *Metal Ind.* (London), 80, No. 9, 163-167 (1952) Feb. 29; *Metallurgia*, 45, No. 269, 121-126 (1952) Mar.; *Light Metals* (England), 15, No. 169, 133-135 (1952) April.

Materials and their present status, the methods available for joining them, and future trends are discussed. The outline of a code of practice is sketched and a new set of sections is proposed, the geometric properties being given. Tentative scantling tables for deck houses and light superstructures are included. Details of the use of aluminum in the new liner "United States" are given.—BNF.

6.7.2, 3.5.9

Boron Carbide as a Base Material for a Cermet. H. J. HAMJIAN and W. G. LIDMAN, *J. Am. Ceramic Soc.*, 35, 44-48 (1952) Feb. 1.

Describes an investigation conducted to determine the bonding mechanism in cermets after exposure at temperatures above the melting point of the metal. Experiments conducted with boron carbide and each of three metals showed that nickel, cobalt, and iron formed a bond between the metal and the ceramic. The properties evaluated were room and elevated temperature modulus of rupture, resistance to fracture by thermal shock, oxidation characteristics, and density. These properties were compared with those of hot-pressed boron carbide. Photomicrographs.—BLR.

6.4.4, 3.7.2

Preparation of High Purity Magnesium and a Study of the Effect of Non-Metallic and Alkali Metal Impurities on the Corrosion Characteristics of Pure Magnesium. *Ninth Quarterly Report* (December 1, 1951—February 29, 1952). Metallurgical Labs, Dow Chemical Co. 1952.

Corrosion studies of the magnesium-

iron binary system indicate that the corrosion properties are significantly affected by the thermal history during casting. The solution potential measurements of magnesium-iron alloys also were found to show a definite relationship to thermal history. Data on the effects of silicon on corrosion of magnesium-iron-silicon alloys and the effects of carbon on the magnesium-carbon and magnesium-iron-carbon systems are included. Data on the corrosion properties of magnesium-chlorine are reevaluated. Vacuum sublimation with argon casting was further investigated as a purification method for magnesium.—NSA.

7. EQUIPMENT

7.1 Engines, Bearings, and Turbines

7.1, 1.6, 2.3.9, 8.9.4

Symposium on Spectrographic Analysis of Diesel Engine Lubricating Oil. May 5-6, 1952. Schenectady, N. Y. Twelve author's remarks at American Locomotive Co., sponsored meeting (1952). 76 pages, 6 x 9 inches, paper bound. Availability not indicated.

An edited transcription of on-the-spot tape recordings of nine technical papers delivered at a symposium sponsored by American Locomotive Company attended by 86 representatives of 43 railroads. The papers show how spectrographic analysis has been adapted to Diesel engine maintenance by railroads. Detailed accounts of railroad experience with the spectrograph are given. It was reported the technique has been developed to the point whereby considerable savings in maintenance and repair are being made by using railroads and breakdowns prevented.

Use of the spectrograph to determine the corrosion and wear qualities of all types of lubricating oils for engine and general machinery use is advocated.

Usefulness of the report is materially hampered by the lack of a topical index.

7.1, 3.5.3

Metallic Lubricants. N. C. AMEN, *Steel*, 130, 86 (1952) March 24.

Presents a study of molybdenum disulfide and copper-lead alloys for their individual as well as collective contribution in maintaining bearing surface areas against wear. Petroleum products serve as a vehicle or binder for these materials.—BTR.

7.1, 3.5.3

Avoid Blade Corrosion and Erosion. W. H. LLOYD, Westinghouse Electric Corp. *Power*, 96, No. 4, 94-97, 206 (1952) April.

Blading failures due to corrosion and erosion can create serious operating problems. Although the 12 chromium-iron alloy resists corrosion, it erodes heavily along the inlet edges of the blades. Increased moisture content accelerates erosive action, especially if solids are present in the steam. To retard this erosion, Stellite is being deposited along the inlet edge or attached in the form of a shield. Illustrations.—INCO.

7.1, 3.5.9

Production and Properties of Discs for Aircraft Gas-Turbine Engines. H. W. KIRKBY, *Metal Treatment and Drop Forging*, 19, 3-11 (1952) Jan.

Describes the types of steel and other high-temperature alloys now available for gas-turbine discs. Mechanical properties and scaling resistance are discussed in detail. Data are graphed and tabulated. 11 references.—BLR.

7.1, 3.5.9, 3.7.2

Symposium on Modern Trends in Non-Ferrous Metals and Alloys. II—High-Temperature Materials for the Gas Turbine. A. R. EDWARDS, Australian Inst. Metals, Sydney Branch, Preprint, 1951, 7-11, *Australasia Engineer*, 1952, 64-68, Feb.

The rotor blade is subjected to the most arduous combination of stress and temp. in the turbine; tensile stress may be ~15 tons/in.², and the temp. ~700° C. at the blade root. Stresses in the disc are comparable, but the temp. is slightly lower. Flame tubes operate at ~900° C., and although unstressed must resist distortion; they are made from sheet material which must be easily formable. Creep-resistance, presented as time/extension curves, is the basis used for design, but for routine acceptance testing a simplified "stress-rupture" test is often used. All the highest-temp. alloys in current production are based on either iron, nickel or cobalt. The matrix structure at operating temperature is i.e.c.; most alloys depend on precipitation-hardening reaction for their high temperature strength, and are used in the "aged" condition. Some details of compn. are: 1) practically all alloys contain substantial amounts of chromium, 2) disc alloys contain >50% iron, 3) rotor-blade alloys and most others contain >50% nickel+cobalt, 4) disc, sheet, and casting alloys contain carbon as a hardener, and 5) in blade alloys other elements are used, and more than one addn. is always present. The high cobalt casting alloys have complex structures, and the constitutional features which confer their high-temperature properties are not fully understood. Most wrought high-temperature alloys have a grain-size larger than structural steels in the range A.S.T.M. Nos. 1-4. Casting alloys are usually coarser. Improvement of existing alloys based on iron, nickel or cobalt is continuing, but these alloys are nearing the limit of their development, and alloys of the higher-m.p. metals such as chromium, titanium, molybdenum, and tungsten, are being investigated. Constitutional studies of chromium alloys contg. beryllium, titanium, and tungsten made in Australia are mentioned. Molybdenum and titanium alloys, ceramics, mixtures of ceramics and metals, and powder compacts are briefly discussed. 14 ref.—MA.

7.1, 5.11

Gas-Turbine Performance and Materials. J. B. BUCHER, *Iron and Steel Inst.* "Symposium on High Temperature Steels and Alloys for Gas Turbines," 1951, p. 17-23.

An indication is given of some of the more urgent metallurgical problems for which the industrial gas-turbine designer awaits solutions. Information on creep resistance, weldability, and corrosion by vanadium pentoxide is given. The need for further research is stressed.—BLR.

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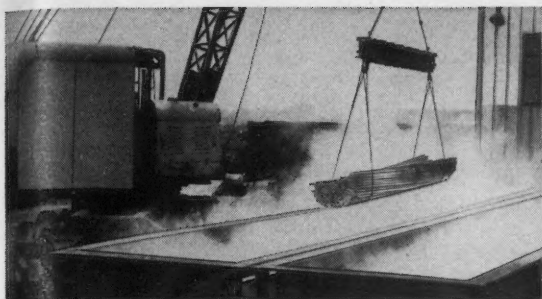
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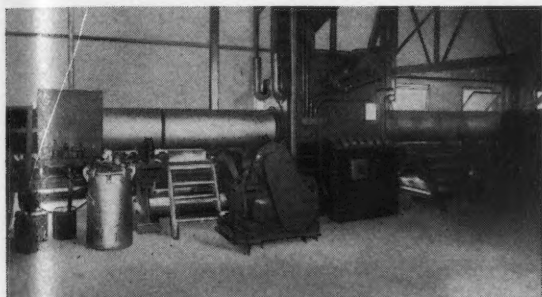
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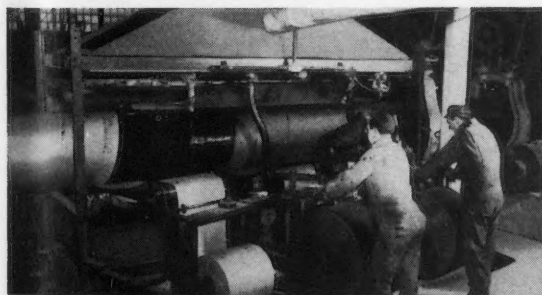
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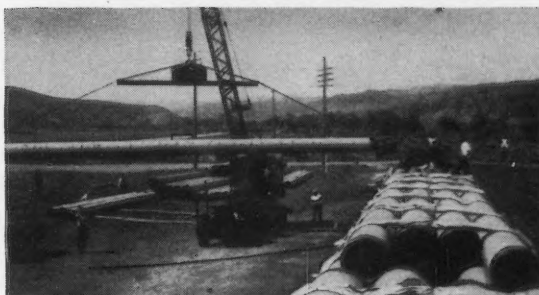
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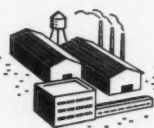


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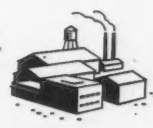


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7.1, 3.5.3, 3.5.2

Fly-ash Erosion in Gas Turbines. M. A. FISHER AND E. F. DAVIS. *Mech. Eng.*, (New York), 71, 481-487 (1949) June.

One of the chief difficulties anticipated in the use of pulverized coal as a fuel for the gas turbine is the possibility of serious erosion of turbine blades and other metal parts by the suspension of fly ash in hot combustion gases. The erosion of metals through the impingement of solid particles suspended in a rapidly moving gas stream is an extremely complicated process which at present cannot be described in exact terms. The high operating temperature of gas-turbine blades introduces special problems in connection with erosion by solid particles. The oxide film which is formed on metal surfaces at high temperatures may well be more brittle and more susceptible to erosion damage than the underlying metal. If this surface film is removed by erosion, exposing more rapid loss of metal. In addition, the heterogeneous nature of some turbine metal to oxidation, then the repetition of this process might lead to a very alloys complicates the situation because the relatively minute particles of fly ash may show a preferential attack on some constituents of the metal structure, resulting in the weakening of stressed parts. In studying the erosion of turbine blades by fly ash at high temperatures, it is thus necessary to investigate possible damage, as well as the overall loss in metal weight. The authors report that the chief features of all erosion tests at high temperature (800° F. to 1350° F.) was the formation of hard tenacious coatings or deposits on the specimens. The exact amount and nature of the deposits varied widely according to the fly ash used and the conditions of impingement. In many cases it was found that both deposit formation and erosion took place on different parts of the same specimen, so that the net result varied from a considerable loss of weight of the erosion test specimen under some conditions to rapid weight gains under other conditions. In general it was found that deposit formation was associated with the impingement of relatively fine ash particles, smaller than about 10 microns diameter, while coarser particles tended to remove any deposits present on the specimen face and to produce erosion of the metal. The deposits produced at high temperature consisted of a hard ceramic-like material ranging in color from a light tan, through various shades of reddish brown, to a dark-red almost black color. Most of the deposits adhered so strongly to the metal surface that they could be removed only with difficulty by using a sharp knife blade. The general appearance and properties of the high-temperature deposits suggested that the fly-ash particles actually were sintered together, even at temperatures as low as 800° F. It appears that the sintering of the fly ash in the deposits must be helped by the pressures developed during impingement as well as by the selective concentration in the deposit of the more plastic constituents of the fly ash.—TIME.

7.1, 3.5.9

Gas Turbines—High Temperature and High-Strength Steels. *Iron and Steel* (London), 23, No. 3, 85-87 (1950) Mar.

Gas turbine development, particularly

in the aircraft field, depends on close collaboration between designers and metallurgists. At present the designer is somewhat limited by the need to use existing materials, although every effort is being made to evolve better steels and other alloys. The designer's requirements are here considered in relation to the materials now available and their properties.

The data on which this article is based are largely taken from Chapter VII of "Gas Turbines and Jet Propulsion for Aircraft" (5th edition) by G. Geoffrey Smith, M.B.E., a review of which appears in this issue.

7.1, 3.5.9, 6.2.5, 6.3.1

Symposium on High-Temperature Steels and Alloys for Gas Turbines—I. *Iron & Steel Inst.*, Feb. 21-22, 1951.

1) In the introductory paper N. P. Allen gives 'A survey of the development of creep-resisting alloys.' The development of such alloys, both ferritic and austenitic, and an account of the general trend of the researches undertaken after 1939 in Great Britain, America and Germany to provide improved materials for use in gas turbines are given. 2) The paper by A. T. Bowden and W. Hrynyszak on 'Materials and Performance' gives an assessment of some of the effects on the performance of the industrial gas turbine resulting from the use of high-alloy steels, which are expensive as regards first cost and fabrication. In the gas turbine these materials are subjected to high temperature and high stresses, and to corrosion, erosion, scaling, etc. 3) The paper by J. B. Bucher, which is entitled 'Gas-turbine performance and materials,' gives an indication of some of the more urgent metallurgical problems for which the gas turbine designer awaits solution. 4) The paper by S. L. Bragg deals with the 'Influence of operating temperature on the design and performance of gas turbines.' 5) 'Stresses in gas-turbine discs and rotors' are discussed by R. W. Bailey. The supplier aspects are dealt with by a number of authors contributing nine papers in all. 6) L. B. Pfeil, N. P. Allen and C. G. Conway review 'Nickel-Chromium-Titanium alloys of the Nimonic 80 type,' 7) while gas turbine steels produced by William Jessop and Sons are referred in a paper by D. A. Oliver and G. T. Harris entitled 'Some proven gas-turbine steels and related developments.' 8) G. T. Harris and W. H. Bailey discuss the 'Effect of warm-working on an austenitic steel (G18B)' and 9) G. T. Harris and H. C. Child describe the development of the cobalt base alloy Jessop G32 for gas turbine rotor blades. 10) The paper by H. W. Kirby and C. Sykes on 'Properties of materials intended for gas turbines' deals with the properties of creep-resisting steels suitable for use in the gas turbine and jet engine. Materials are classified under (a) ferritic steels and (b) austenitic steels. 11) The same authors contribute a 'Study of the properties of a chromium-nickel-niobium austenitic steel,' which is a study of the properties of wrought 18/10 chromium-nickel steel stabilized with niobium. 12) The results of an investigation of 'Creep-resisting ferritic steels of the 3 percent

Cr-Mo-W-V type are reported by E. W. Colbeck and J. R. Rait, while 13) H. H. Burton, J. E. Russell and D. V. Walker contribute a paper on 'Ferritic steels for gas turbines,' in which the authors give test results on three ferritic steels, mainly of the 3 percent Cr-Mo-W-V type. 14) The paper by W. E. Bardgett and G. R. Bolsover deals with 'Special steels for gas turbines,' and gives properties of a 25 percent chromium, 15 percent nickel type steel, suitable for combustion chambers. Data on a steel containing about 20% of chromium, 30% of nickel and 1% of titanium are also given.—TIME.

7.1, 3.5.9, 6.3.4

Sintered Alloys for High-Temperature Service in Gas Turbines. R. W. A. BUSWELL, W. R. PITKIN, AND I. JENKINS. Gen. Elec. Co. Ltd. Paper, Iron & Steel Institute, London, Feb. 21-22, 1951.

Symposium on High-Temperature Steels and Alloys for Gas Turbines, Feb 1951, 258-268; *Metallurgia*, 43, No. 258, 166-168+ (1951) Apr.; *Metal Progress*, 59, No. 5, 653-656 (1951) May.

A cobalt-base alloy of the Vitallium type containing 30 chromium-6 wolfram (tungsten) was prepared by powder metallurgy and its properties compared with those of the cast alloy. The room temperature properties compared favorably, but, at high temperatures, although the fatigue properties of the sintered material are encouraging, the creep properties above 600° C. are low. The possibility of improving the high-temperature strength by the introduction of refractory oxides such as thoria is discussed. The low strength in creep may be associated with the absence of the intergranular carbide networks found in the cast alloy, and possible methods of introducing carbon into the sintered alloy are described. The sintered alloy is very sensitive to heat-treatment. The effect of ageing on mechanical properties was investigated and the significance of crystallographic transformation is discussed. Photomicrographs. 11 references.—INCO.

7.1, 2.2.4, 5.8.2, 8.9.4

How Laboratory Controls Aid Diesel Maintenance. *Ry. Age*, 130, No. 15, 33-36 (1951) Apr. 16.

Alkaline-sodium-chromate treatment was standardized after various corrosion inhibitors were tested in the laboratory. The organic corrosion inhibitor, compatible with ethylene glycol type antifreeze was used in 25 test locomotives. Weekly samples were taken to test the effective corrosion inhibitor left by measuring the reserve alkalinity and cylinder line assemblies in engine crankcases were inspected monthly to see if any corrosion was occurring.—INCO.

7.2 Valves, Pipes and Meters

7.2, 3.5.3, 8.1.4, 3.4.6

Erosion of Domestic Water Fittings. S. G. BARRETT. *J. Inst. Water Engrs.*, 6, No. 2, 145-154 (1952) Mar.

Includes a statistical survey of defective tap seatings (1943-1951) by the Newcastle and Gateshead Water Company, and experimental investigations of the effect of chlorine on the corrosion of fittings. They conclude that corrosion



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Improved phenolic-type lining for drums

Phenolic coatings are the dependable "workhorse" of the drum lining industry. They have long been favored by packaging engineers for use in steel containers to protect the package from corrosion and the contents from contamination.

Unichrome Series B-124 Linings have been acknowledged by many users to be outstanding improvements in this type of material. They bake into extremely tough and durable linings that have excellent adhesion and unusual ability to withstand strong acids, oils, food chemicals, vinegar, wetting agents. Solvents such as benzene and ketones also have no effect on B-124 linings.

Other linings also available for other products. Write for data, and for information on manufacturers and reconditioners supplying drums with Unichrome Drum Linings.

Coatings have definitely become important materials of construction to the chemical or corrosion engineer. With many types of coating materials available to meet unusual requirements, no longer is surface protection being classed as merely another paint job. Instead, many plants are thinking of maintenance painting as an engineering problem, to be solved by an engineering approach.

Such an approach can make a big difference in results — both in longer lasting equipment and more durable paint jobs.

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Engineering a solution to a painting problem means devoting proper attention to surface preparation for the coatings which are to be applied. It means specifying a system or combination of coatings devised for the service conditions encountered.

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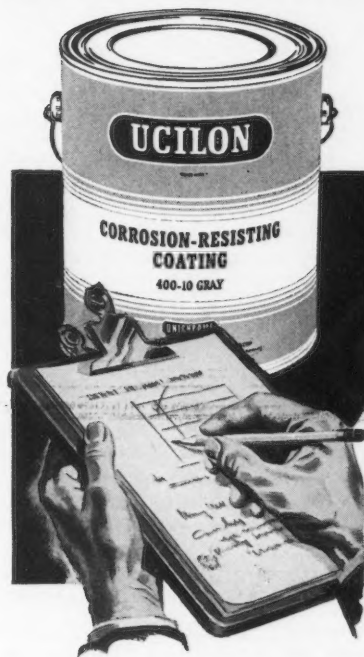
Generally, the tougher the corrosion problem, the more attention the surface needs. Sometimes this includes careful mechanical preparation. Experience has shown that, when required, one of the most important steps is also priming. This contributes to better adhesion of subsequent top coats. It adds extra corrosion resistance and minimizes undercutting of the protective film in the event of a break in its continuity.

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Systems of Ucilon Coatings form effective barriers to a hundred and one tough, corrosive conditions. Many such systems are available to permit the engineer to specify a material that protects against intermittent or continuous contact with acids, alkalies, salt solutions, alcohols, moisture, oils, chemical compounds and other products.

Protection provided by Ucilon Coatings is based on vinyl, chlorinated rub-



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"AN OUNCE OF PREVENTION"

Preventive maintenance was always a good idea. Today it can be considered virtually vital in order to end needless corrosion of equipment and avoid the production delays, costly downtime and replacement headaches that such damage entails. Ucilon Coatings Systems can help you achieve longer lasting protection at lower cost and make your preventive maintenance more effective.

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of hot-pressed brass in ball valve seatings is rapidly accelerated by the action of chlorine in the water. Tests on other alloys were also carried out.—BNF.

7.2, 6.4.2, 8.9.3, 4.1

Some Corrosion Experiences With Aluminum Crude Oil Lines. ALMONT ELLIS. Paper presented at South Central Region Meeting, National Association of Corrosion Engineers, Corpus Christi, Texas, October 17-20, 1951. *Corrosion*, 8, No. 8, 289-291 (1952) Aug.

Experience of Interstate Oil Pipe Line Company with 635-T6 extruded aluminum pipe substituted for steel pipe in Southwest Arkansas and the Louisiana Gulf Coast indicates that:

- 1) Efficiency of the inert gas arc welded joint is not very high, partial annealing of a zone about an inch from the weld proper having about 60 percent of the original ultimate strength of the untouched alloy.
- 2) Two quarter mile sections of 4-inch suction line laid in Arkansas failed in a little more than 25 months as the result of pitting at annealed areas.
- 3) One of two installations of 6-inch discharge lines pitted at points where iron sulfide scale accumulated and was replaced in a little more than three years. The second discharge line handles sour crude, natural gasoline, propane and butane and is still in use; but leaks at annealed areas indicate it will need replacing soon. Tests indicate exclusion of iron sulfide would eliminate practically all internal corrosion.
- 4) External corrosion at water crossings in Arkansas was observed in the form of 1/16-inch pits after 16 months.
- 5) A half mile of 4-inch line laid in South Louisiana marsh shows no evidence of external corrosion after 3½ years although partly submerged in salt water.

7.3 Pumps, Compressors Propellers, and Impellers

7.3, 8.9.5, 3.2.2

Cavitation and the Propeller of Maximum Efficiency. W. LAMBIE. *Marine News*, 37, 21 (1950) Nov.

Cavitation appears to be due to two major causes, either high thrust per unit area of projected surface or operation at incorrect slip ratio. In the first case the tendency, particularly with manganese-bronze propellers, is for the whole of the propeller to become dezincified, and in the second case the blades will be eroded on one side or the other. The author quotes the conclusions reached by the Propeller Sub-Committee of the Board of Invention and Research published in 1917, and gives confirmatory examples from his own experience. He suggests that erosion, even if it shows only as a polished surface, is a sure sign of breakdown of the streamline flow; and that the presence of green vegetable matter, or even living shells, indicates that the water is flowing smoothly over the propeller without cavitation. A singing or whistling propeller also indicates the presence of cavitation and shows signs of erosion on the blade faces. Both the whistling and the erosion disappear when a propeller of correct dimensions is installed. Many Liberty ships had propellers that sang at the light-load condition and the author states that the large number of shaft failures in these vessels may be the result of incorrect propellers rather than of critical vibration in the shafting of engines.—TIME.

7.4 Heat Exchangers

7.4.2, 3.5.3

The Distinguishing Characteristics of Boiler Tube Failures. FRANK E. CLARKE. *J. Am. Soc. Naval Engrs.*, 64, 83-94 (1952) Feb.

Discusses the above. "Cavities" and "scars" are defined as pits, grooves, gouges, and wasted areas which have resulted in obvious internal or external loss of tube metal, without evidence of abnormal temperatures. They include generalized corrosion, steam gouging, and mechanical scars. "Cracks and fissures" category includes all failures which occur as narrow slits or crevices without significant deformation of tube shape or loss of metal. The various types are illustrated.—BTR.

7.4.2, 4.6.2, 6.2.4, 8.4.3

How to Combat Heat-Exchanger Corrosion. A. R. DYER. Richfield Oil Corp. Paper before N.A.C.E. Mtg., Los Angeles, Sept. 1951. *Oil Gas J.*, 50, No. 39, 69, 84 (1952) Feb. 4.

Improved methods of cathodic protection and the development of new alloys are the trend in struggle against corrosion in the refineries of the petroleum industry. Types of corrosion in tubes in water service in a refinery are discussed and preventive measures are suggested. Carbon-steel tubes are mostly used in a refinery in steam service where corrosion is caused by oxygen and carbon dioxide gases. Four methods of combating this type of corrosion are treatment of the boiler feed to minimize the amount of gases entrained in the steam, improved design of condensing equipment, chemical treatment of condensate, and the use of corrosion-resistant metals and alloys. The most common corrosives in exchanger tubes in oil service in a refinery are the sulfur compounds. The use of low and intermediate chromium steel is the only way to defeat this type of corrosion in exchanger tubes, 4-6 or 6-8 chromium, ½ molybdenum tubes being the most practical solution. Although aluminum exchanger tubes have not been used in the Watson refinery of Richfield Oil Corp., others are reported to have successfully done so. 6 references.—INCO.

7.4.2, 4.6.9, 4.6.4, 8.4.3

Salt-Water Corrosion in Refinery Cooling Equipment. B. M. BEILDECK AND O. F. NOSS, JR. Union Oil Co. of Calif. Paper before Calif. Natural Gasoline Assoc., Fall Mtg., 1951. *Oil Gas J.*, 50, No. 45, 296, 299-300, 302 (1952) Mar.

Study of salt-water corrosion in refinery cooling equipment was conducted. Tube replacement records were reviewed and changes in composition of the salt water in respect to foreign matter such as sand marine life and dissolved oxygen were investigated. The possibility that excessive tube-skin temperatures in the exchangers might be contributing to the increased rate of corrosion was investigated. Corrosion manifests itself as oxygen concentration cell attack, erosion-corrosion, hot-wall effect, or galvanic attack. Currently phosphorized Admiralty tubes are being used, and in submerged bundles, stud bolts, and outlet heads are of solid Monel. Channel covers are of Monel-lined steel.—INCO.

7.4.2, 5.7.1

How You Can Avoid Boiler Tube

Corrosion. H. F. HINSTR. Babcock & Wilcox. *Heating, Piping & Air Conditioning*, 24, No. 3, 77-83 (1952) Mar.

Study of the causes of boiler tube failures shows that the service life of tubes is dependent primarily on the environment, or the conditions of operation of the boiler. Proper operating and maintenance procedures should be followed regularly to prolong tube life, reduce re-tubings and cut costs. The types of corrosion discussed include atmospheric, fire-side, pitting, water-line, concentration cell, galvanic and erosion-corrosion. General rules for avoiding corrosion in boiler tubes are: make sure boiler water is sufficiently alkaline, free of oxygen and chemically treated; keep boiler fittings tight to keep air out, and preferably use a fuel with low sulfur content, to avoid the corrosive action of sulfur gases. Graphs and illustrations are included.—INCO.

7.4.2, 6.2.2, 8.4.2

Cast Iron Cooling Sections Pare Costs, Repel Corrosion in Coke Plants. *Gas*, 28, No. 5, 49-50 (1952) May.

Gray cast iron cooling sections replaced steel pipe coil cooling equipment for wash oil used in the light oil recovery process and ammonia liquor for direct contact cooling of coal gas in producing by-products at the Hunts Point coke plant of Con. Edison and the Everett plant of Eastern Gas & Fuel Assoc. The cast iron cooling sections are resistant to corrosion to sea water used for cooling, more compact, cost less to operate, easy to maintain and have high thermal efficiency. The wash oil cooler consists of 19 stacks. Life of the galvanized steel pipe coils used for cooling ammonia with sea water at the Everett coke plant was 18-20 months when they developed leaks from corrosion. Installations of National sections are discussed. Illustrations.—INCO.

7.4.2, 7.1, 8.2.2

On-Load [Power Station] Turbine Condenser Cleaning. H. W. HUTTON. *J. South African Inst. Mech. Eng.*, 1, No. 6, 142-146 (1952) Jan.

Periodic introduction of compressed air into the condenser tubes during operation prevented fouling up with mud deposits, without accelerating corrosion-erosion of the tube inlet ends.—BNF.

7.4.2, 8.2.2

Boiler Tube Corrosion in British Power Stations. E. W. F. GILLHAM AND R. L. REES. Paper before Am. Power Conf., Chicago, Mar. 26-28, 1952. *Combustion*, 23, No. 10, 39 (1952) April.

Results of a survey of 94 power stations in which ⅓ showed boiler tube corrosion are reviewed. Corrosion occurred in low heat transfer and more commonly in boilers operating under pressures under 400 psi. In zones of high heat transfer, low alkalinities and high concentrations of neutral salt and of dissolved oxygen in the feedwater seemed to promote it. Corrosion appeared to produce scabs of magnetic ferrous oxide having a laminar structure in radiant sections. Additions of alkaline substances appeared beneficial. Sodium sulfate is used as a scavenger in these stations but is not protective where the dissolved oxygen is high (over 0.1 ml per liter). Maintaining oxygen concentration below 0.03 ml per liter and the use of sodium sulfate appear to be the best protection. Metallic copper and cupric oxide were observed at a number of stations but

there was no evidence that copper deposits were responsible for tube corrosion. A few instances of caustic embrittlement are given.—INCO.

7.4.4, 5.10

How Gulf Oil Corp. Reduces Furnace Tube-End Corrosion. F. C. BRAUN. *Oil Gas J.*, 50, 285-286, 288-289 (1952) Mar. 17.

Excessive deterioration in the rolled ends of carbon or low-alloy steel tubes is related to stresses set up during expansion, distortion of metal structure, and erosion caused by turbulence at the internal offset formed by the expander during the rolling operation. Other remedial methods evaluated are safe ending, high-alloy end liners, and inside-upset tube ends.—BTR.

7.4.4, 8.4.3, 3.5.9, 3.4.8

Magnolia Reduces Furnace Corrosion in Polyformer. J. J. BAKER. *Magnolia Petroleum Co. Oil Gas J.*, 50, No. 45, 306, 309, 316 (1952) Mar.

With installation of higher-alloy furnace tubes and heater material in the polyformer furnaces at Beaumont, corrosion of equipment was reduced and maintenance costs lowered. Materials now in use are from 2 chromium- $\frac{1}{2}$ molybdenum to 9 chromium-1 molybdenum. Corrosion experienced in these furnaces was of the high-temperature sulfur corrosion type and follows a definite corrosion-temperature relationship. Graphs.—INCO.

7.5 Containers

7.5.5

Collapsible Drum. *Modern Packaging*, 24, No. 9, 89 (1951) May.

A brand-new idea in drums—a non-rigid synthetic rubber-fabric container holding 55 gal, which may be collapsed for return and re-use—has attracted several users in the petroleum and liquid-chemical fields and may have widespread usefulness in the current metal shortage if the materials from which it is made do not prove to be shorter than steel itself. It is currently being produced only in limited quantities and at this stage, of course, the drums are more expensive than steel. The drum was not, however, developed as a substitute; it has several interesting features. Principal advantages claimed are 1) the collapsible space-saving feature, 2) lightweight which permits substantial savings in shipping costs, and 3) ability to absorb punishment that would destroy or damage a metal or fiber drum. Experimental tests have indicated that the new drums will be suitable for the shipment of oils, greases, fats, acids, paints, emulsions, soaps, dry powders and a variety of pharmaceutical and industrial chemicals. They are also being tested for the practical transporting of liquids by air for military purposes and for dropping liquids by means of parachute to ground troops.—TDP.

7.5.5, 4.6.2

Corrosion History of a Domestic Hot Water System. JOHN R. BAYLIS. *J. Am. Water Works Assoc.*, 44, 224-238 (1952) Mar.

Describes and analyzes the condition of a hot-water tank after 22½ years of use. The tank was galvanized iron, 30-gal. capacity, with metal thickness of 0.08 inch. It was connected to a furnace heater and to a gas heater.—BTR.

7.5.5, 6.2.5

Investigation of Failure of Type 347 Stainless Steel Tank for Lithium. F. J. LAMBERT AND C. COUGHLIN. U. S. Atomic Energy Commission, Y-694, Nov. 8, 1950, 22 pp.

A Type 347 stainless steel, 18 chromium, 12 nickel, 0.7 niobium (columbium), 0.11 carbon, tank made from welded tubing had 16 Inconel-sheeted Calrods brazed to it longitudinally. The tank, used to handle molten lithium, cracked along the edge of the braze metal holding the calrod on top of the tank longitudinal seam weld. The stainless steel did not contain the proper proportion of carbon to niobium (columbium) and therefore was more susceptible to carbide precipitation. The cracking was due to this precipitation and to residual stresses from cold working. Photomicrographs.—INCO.

7.5.5, 5.8.2, 5.3.2

Inhibiting Corrosion of Hot Water Tanks. *Chem. & Process Eng.*, 33, No. 5, 253 (1952) May.

A survey of the failure of domestic hot water tanks after a short time in service was made by the Canadian National Research Council. Analyses included photomicrographs of zinc coating on steel tanks that had failed in service. As far as corrosion of galvanized steel water tanks is concerned, large heaters (3 kW) operated by hand are better than small heaters (500 W) automatically controlled because with the large capacity heaters storage of hot water in the tank during the night is unnecessary. Several of the thermostats which should be used only as safety devices were found inaccurate. Addition of corrosion inhibitors to the water just before it enters the tank is the most practical way to improve the service life of galvanized tanks.—INCO.

7.6 Unit Process Equipment

7.6.4, 3.2.2

Steel, Heat and Water: Localized Formation of Magnetic Iron Oxide in Power Boilers. H. M. RIVERS AND W. M. SONNETT. *Blast Furnace and Steel Plant*, 38, 694-696 (1950) June. *Proc. Midwest Power Corp.*, 12, 114-121, (1950).

Pitting corrosion, attack on a heat-transfer surface by caustic in concentrating film, caustic attack under adherent deposits, hydrogen damage, effects of temperature and corrosion fatigue.—MR.

7.6.4, 5.8.3, 3.4.6, 5.3.4

Mercury Boiler Treatment with Titanium and Magnesium Metals. R. C. REID, Gen. Elec. Co. Paper before ASME, Spring Mtg., Atlanta, April 2-5, 1951. *Combustion*, 22, No. 10, 56-57 (1951) April.

Action of titanium and magnesium metals in protecting boiler steel from attack by mercury is discussed. Phase diagrams of the mercury-iron, mercury-titanium and iron-titanium systems are used in explaining the mechanism of the dissolving action of the metals. Titanium, in sufficient amount to saturate the system, will protect a boiler surface from attack by mercury and an excess of titanium will satisfy requirements of metal surfaces and replace any loss through the condensing system or removal by depositing. In large mercury boilers, titanium is not satisfactory for

the control of oxygen, so magnesium is used as the deoxidizing agent. Magnesium reduces titanium oxide and prevents its oxidation, thereby keeping this metal active in the boiler system.—INCO.

7.6.4, 3.2.2

How Boiler Steel Can Disappear. HARRY M. SPRING. *Power*, 94, 116-117 (1950) Oct.

Various forms of corrosion attack, their causes and prevention.—MR.

7.6.5, 6.1

Evaporation. J. M. COULSON. *Intern. Chem. Eng. Process Ind.* 33, No. 3, 127-136 (1952) Mar.

The materials of construction used in vacuum evaporator for the refining of salt are discussed. The internal mechanism is of stainless steel or steel protected with phenolic coating. The scraper conveyor is of Monel. The evaporator has cast iron bodies with steel tube sheets and copper tubes. Circulation is increased with Monel propellers on stainless steel shafts. Monel pipelines are considered more effective with hot brine than stainless steel. Ni-Resist is used for hot brine pumps. The calandria consists of copper tubes. Illustrations. 20 references.—INCO.

7.6.8, 8.4.3, 4.3.2

Low-Temperature Corrosion in a Crude-Distillation Tower. T. N. GRISWOLD. *Continental Oil Co. Oil Gas J.*, 50, No. 45, 247-248, 250, 255 (1952) Mar. 17.

Experience with crude-distillation tower points out how low-temperature corrosion of trays can be extremely troublesome when not combated with all possible practical measures. The main cause of the damage is believed to arise from hydrogen chloride formed in the hydrolysis of the various chloride salts in the raw crude. In addition to hydrogen chloride, hydrogen sulfide is also a corrodent in the top section of the tower. From observations, it is believed that heavy maintenance expenditures will be held down since the ammonia injection and crude desalting are carefully operated. The most economic material for internals is apparently Monel.—INCO.

7.7 Electrical, Telephone and Radio

7.7, 6.6.7, 6.3.8

"Lepeth" Sheath for Telephone Cables. E. J. LARSEN AND R. B. FARRELL. *Elec. Eng.*, 69, No. 11, 1014-1017 (1950) Nov.

The sheath structure consists of a polyethylene jacket extruded on the cable core, over which a relatively thin lead sheath is applied. The manufacturing process is described in detail. Main application mentioned is protection against lightning.—BNF.

7.7

The Problem of the Corrosion of Armatures in Contact With Impregnated Wood. (In German.) F. MOLL. *Werkstoffe u. Korrosion*, 2, 14-15 (1951) Jan.

Demonstrates briefly the inadequacy of short-time laboratory tests on wood preservatives, since it was found in practice that they often promote, rather than inhibit, the corrosion of metals joined to, or in contact with, the wood.

The corrosion of nails driven into

wood impregnated with $(\text{NH}_4)_2\text{SO}_4$, ZnCl_2 , acid fluorides or HgCl_2 , can be prevented by lacquering the nails.

7.7, 5.3.4, 5.4.5

Electric Metallic Tubing Given Protective Coatings. *Iron Age* (U.S.A.), 167, No. 13, 96 (1951) Mar. 29.

A short note on the finishing of welded light-weight steel conduit. The tubes are made in 10-foot lengths and are zinc plated externally and coated with a clear lacquer internally. During plating they are held vertically in cages.—ZDA.

7.8 Wires and Cables (Non-Electrical)

7.8, 6.4.2

Aluminum-Sheathed Impregnated Pressure Cable. *Machinery Lloyd*, 22, No. 10, 99 (1950).

Aluminum-sheathed cables are now available in a range of sizes and types. The sheath of an impregnated pressure cable is required to withstand an internal nitrogen pressure of 200 pounds per square inch. Aluminum cables, unlike lead, do not require an external steel reinforcement. Corrosion of aluminum in the buried condition is no greater hazard than when using lead and steel reinforcement. The fatigue endurance of aluminum is much higher than lead and it is unnecessary to take any special precautions for aluminum-sheathed cables installed in positions where vibration is severe.—MA.

8. INDUSTRIES

8.1 Group 1

8.1.2, 5.3.4, 5.4.8

Protection of Structural Steel Against Atmospheric Corrosion. J. C. HUDSON AND W. A. JOHNSON, *J. Iron Steel Inst.*, 168, No. 2, 165-180 (1951) June.

Part I. Hudson discusses the problem mainly theoretically, quoting the results of research as guides to the principles to be followed in devising protective treatments for steelwork. The value of zinc coatings is mentioned and there are brief notes on preparing hot dip galvanized surfaces for painting. It is considered doubtful whether red lead primers should be used on zinc or on any other metallic coatings.—ZDA.

Part II. Ways and means are considered by which principles may be put to industrial use. The conditions which a "mass-produced" coating should fulfill and some dependable coatings, which are assumed to be painted later, in the usual way, are discussed. Illustrated. 13 references.—BLR.

8.1.4, 7.2

Water Main with Sulfur Joints Suffers Its 69th Baffling Break. *Eng. News-Record*, 148, No. 11, 62 (1952) Mar. 13.

A special committee, appointed to investigate the breaks in Honolulu of a 10,500 foot pipeline, found that most of the breaks occurred where the pipe was at or below sea level. The sulfur joint material undergoes a chemical change resulting in volume expansion creating hoop stress in the pipe bell. The rate of chemical change is proportional to the degree of corrosiveness of the soil—primarily, and the amount of sea water

in the soil. A research project was undertaken to clarify the problems of disintegration, stress, and strain, and corrosion of cast-iron pipe joints made with sulfur compounds. The conclusions of this investigation are outlined. Photographs are included.—INCO.

8.2 Group 2

8.2.2, 1.2.2, 5.1, 4.1

Why Power Companies Should Promote Corrosion Control. H. H. ANDERSON. An address before the Twenty-Third Anniversary Meeting of the Petroleum Electric Power Association, Houston, Texas, Nov. 20, 1951. *Corrosion*, 8, No. 8, 278-282 (1952) Aug.

Utility management is asked if it can

afford to ignore its responsibility to promote corrosion control on its own systems in view of the extensive damage corrosion causes to iron, steel, lead cable and galvanized duct exposed to water. Engineering methods of minimizing corrosion damage are reviewed, with frequent examples of the varying corrosion problems found among utilities. References to discussions of various kinds of corrosion and the methods used to combat it in electric power, steam generating and other utility plants are given.

8.4 Group 4

8.4.3, 5.9.2

Corrosion and Scale Control. EDWARD

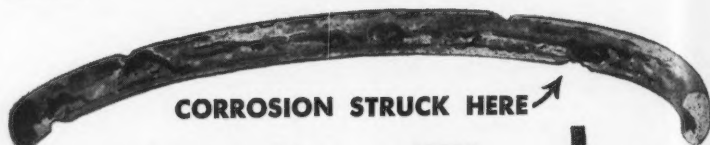
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N. JONES. *World Oil*, 133, 204, 208, 210 (1951) August.

The versatility of acids as well as correct application for removal of carbonate scale, cleaning well bores and retrieving stuck liners. Case histories of wells successfully treated with scale-removing compounds are cited.—MR.

8.4.1, 8.4.2, 8.4.3, 4.4.9

Shortages. U. R. EVANS. *Metal Ind.* (London), 78, No. 18, 366 (1951) May 4.

Dr. Evans, in this letter, makes a plea for investigation into the possibility of removing sulphur compounds from fuel before it is burnt. Though it might not be practicable to make the sulphur available in a useful form, the consequent elimination of sulphur compounds from flue gases would lead to a great saving in non-ferrous metals, as corrosion resisting coatings would last much longer. The reduction of the sulphur-content of steel would also increase its corrosion resistance. Methods of achieving this end are mentioned.—ZDA.

8.4.3

What Causes Tubular Failures? D. C. NEELY. *Oil Gas J.*, 50, pt. 1, p. 78-80, 116-118 (1951) May 31.

Describes a few typical examples of casing and drill-pipe failures. Each type of failure is illustrated. Discusses possible causes and remedies.

8.4.3, 1.1, 5.1

Case Histories of Corrosion Problems and Use of Protective Coatings in Their Solution. I. Interior Tank Corrosion. W. B. COOK. Gulf Oil Corporation. *Oil & Gas J.*, 50, No. 45, 313-316 (1952) Mar. 17.

Protective coatings used to control interior corrosion of tankage in sour-crude service at Gulf Oil Corp.'s Port Arthur refinery are discussed. A five-coat vinyl coating system has appeared effective to date; surfaces are prepared by sand-blasting. In some cases rotary wire brushing treatment with weak phosphoric acid metal conditioner, wiping with solvent have supplemented the sandblasting preparation, and to the vinyl coating is added a two coat application of alkyl red lead primer followed by more vinyl coating. Polyethylene tape gives good protection for piping. Paints and other protective coatings are discussed.

8.4.3, 1.7.1, 1.2.2

Sour Oil Well Corrosion TP-ID-Sour Oil Well Corrosion. J. A. CALDWELL. Presented as a TP-ID Report, National Association of Corrosion Engineers. *Corrosion*, 8, No. 8, 292-294 (1952) Aug.

The problem of corrosion in oil wells producing hydrogen sulfide has been a serious one for several years. Efforts to reduce the monetary losses due to this type of corrosion are now being intensified. In some areas, corrosion progresses at a rapid rate; tubing leaks or rod breaks may occur on an average of one every thirty days. Pumps may have to be pulled at frequent intervals, either because of corrosion of the pump or because of corrosion products from the pipe accumulating in the pump. Recent developments indicate that internal corrosion of casing in the vapor space is occurring in some areas.

A group for the study of sour oil well corrosion, designated Sub-committee TD-ID, was organized early in 1950. A preliminary survey of the extent of the problem has been made in the Arkansas,

Kansas, and West Texas-New Mexico areas. A total of 8,215 sour-crude wells were reported; of this number, 3,618, or about 44%, were listed as being economically affected by corrosion. Costs of corrosion before the application of remedial measures ranged from an average of \$270.00 per well per year in the West Texas-New Mexico area to \$2000.00 per well per year in the Kansas area. Substantial reduction in the cost of corrosion has been effected in some cases by the application of various remedial measures.

8.4.3, 2.2.3, 5.8.2

Corrosion Control in Gas-Lift Wells. D. A. SHOCK AND J. D. SUDBURY. A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, 8, No. 9, 296-299 (1952) Sept.

Severe corrosion was found to be taking place in the South Texas oil wells where producing pressures were not abnormally high. Most of these wells were produced by gas lift. An investigation was instigated to study the causes of the corrosion and find some means of bringing it under control. An Otis type "F" tubing stop was developed to hold a specially designed coupon so that the corrosion rates could be checked at various levels in the tubing. The studies indicated that the rates of corrosion followed the general corrosive criteria set up for condensate wells when the pressure conditions at given depths and temperatures and CO_2 contents were considered. The top-hole coupons did not reflect the actual severity of corrosion which could be taking place down the hole in the same manner as they do in condensate wells. It was also found that in these gas-lift wells a considerable height of water column was present in the annular space, and any successful inhibition method had to be so designed that the inhibitor would mix in the water and diffuse through it to fall to the bottom. Oil soluble and emulsifiable inhibitors were therefore found to be unsatisfactory, because they were blown through the gas-lift valves and never reached the bottom of the tubing. General factors governing corrosion mitigation problems in these oil wells are discussed.

8.4.3, 2.3.4, 5.8.2, 4.6.9

Laboratory Apparatus for Studying Oil Well Subsurface Corrosion Rates and Some Results. PAUL J. KALISH, J. A. ROWE, JR. AND W. F. ROGERS. Gulf Oil Corporation, Houston, Texas. A paper presented at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952. *Corrosion*, 9, No. 1, 25-33 (1953) Jan.

An apparatus has been constructed for studying the corrosion rates of oil well brines under conditions simulating those at the bottom of the well. It has been found that when carbon dioxide or hydrogen sulfide is recombined with a well fluid to under-ground conditions the fluid is frequently acid in character. Such acidity, coupled with a high fluid temperature, and the absence of an oil with protective properties, is believed a primary cause for high subsurface corrosion rates. A method of testing inhibitors is described. Data are presented showing mercaptans to act as inhibitors of corrosion. Such compounds could be

naturally occurring inhibitors of sulfide fluids.

8.4.3, 3.4.3

Diagnosis of Chemical Corrosion and Deposits in Oil Well Production. F. FISHER. *Calif. Oil World*, 45, No. 3, 11-12 (1952) Feb.

Oil well corrosion is often caused by an unbalanced carbon dioxide-bicarbonate system in which either bicarbonate is precipitated as a scale, or excess dissolved carbon dioxide corrodes. Methods of diagnosing these conditions are briefly noted. The correction and detection of the unbalanced bicarbonate saturation water condition is said to be simple. No details are given.

8.4.3, 7.2

Sweet Oil Well Corrosion. H. L. BILHARTZ. *World Oil*, 134, 208, 210, 213, 214, 216, (1952) April.

Above problem at high and low pressure are briefly discussed from the standpoints of investigative approach, criteria, causative agents, and remedial measures. Preliminary findings of representatives of 30 companies are given. Includes use of plastic-coated tubing, nickel tubing, and galvanized or nickel-plated pipe. Diagrams and photographs.—BTR.

8.4.3, 7.2

How to Predict and Control Sweet-Oil-Well Corrosion. H. L. BILHARTZ, Atlantic Refining Co. *Oil Gas J.*, 50, No. 50, 116-118, 151, 153, (1952) April 21.

Caustic agents and remedial measures for low- and high-pressure corrosion are discussed. To prevent high-pressure corrosion, 9 nickel steel tubing was installed in one area of southeastern Louisiana and is in perfect condition after 1 year's service. Galvanized and nickel-plated pipe were tested. Galvanizing failed immediately and results of nickel-plated tests are not available. Low-pressure corrosion was first observed two years ago and preliminary data is given. Inhibitor injection is, generally, the most economical remedial action. Iron loss in relation to corrosive attack is considered. A water analysis check and coupon exposure tests can dictate remedial action. A present problem is the collection of data. Tables, photographs.—INCO.

8.4.5, 6.3.1, 6.7.2

Wanted: Better Materials for Nuclear Reactors. GEORGE E. EVANS. *Iron Age*, 169, 93-97 (1952) March 13.

Reactors resemble huge heat exchangers, and materials must have satisfactory physical and thermal properties. Titanium, zirconium, and beryllium offer possibilities as construction materials. Bismuth, lead, sodium, and potassium can be used as liquid metal coolants. Ceramics and ceramic-metallics offer unusual mechanical properties at high temperatures. Several new alloys are suggested.—MR.

8.5 Group 5

8.5.3, 4.3.2

The Future and Application of Ammonium Bisulphite Pulping. T. E. DETCHER AND R. M. JONES. Paper before American Pulp & Mill Superintendents Assoc., Northwest Div., Minneapolis, May 4-5, 1951. *Paper Ind.*, 33, No. 12, 1438-1442 (1952) Mar.

A discussion on the ammonium bisul-

phite pulping process considers development of the process, raw materials, equipment, acid making, digester operation, wood utilization, papermaking with ammonia base pulp, economic considerations, and waste sulphite liquor disposal. Ammonia and calcium base pulping is compared under hypothetical set of mill conditions. As to the corrosive properties of the ammonia base acid, it was found desirable to replace bronze with alloy steels in acid pumps, steam nozzles, tower, tank, and digester fittings and strainers. Stainless piping valves or fittings in sound condition will give satisfactory service with the ammonia base acid and will run their present normal life. One of the advantages of this process is removal of scale deposit after short contact with the acid. Tables.—INCO.

8.5.3, 4.3.5, 6.1

Chlorine Handling in Pulp Mills. E. L. CROWLEY. Inflico Inc. *Paper Ind.*, 33, No. 11, 1311-1312 (1952) Feb.

Flexible metal hose of Monel, stainless or copper, copper figure S-bends or flexible elbows (Barco type) are different ways to hook a car to the mill lines. Two methods of packing chlorine valves to hold gas and be of free movement are a bellows-sealed valve which has Monel or stainless steel bellows and Teflon packing. Two valves in sat-

isfactory service for 18 months are packed with 2 rings of Teflon and the balance of the stuffing box is filled with a Monel ferrule. While wrought iron works well with dry chlorine, either liquid or gaseous, it lasts only a few minutes in the presence of water and chlorine. Consequently Hastelloy C pipes and valves where chlorine and water are intermixed as when feeding chlorine into a pulp slurry are necessary. Once chlorine is in water solution hard rubber lined equipment is necessary.—INCO.

8.5.3, 6.3.6

The Manufacture and Use of Fourdrinier Wire Cloth. A. G. HOSE, AND J. P. JOHNSON. Lindsay Wire Weaving Co. *Wire & Wire Products*, 27, No. 3, 249-254, 313 (1952) Mar.

Study of the manufacture and use of Fourdrinier wire. The current Fourdrinier warp alloys are phosphor bronzes with 7-8 tin, 0.2-0.3 phosphorus and balance copper, which withstands wear and fatigue and resists corrosion. Brass has remained satisfactory for the filler except in isolated cases where corrosion conditions require a 3 tin bronze. In some instances seams are sewed with stainless steel, but most manufacturers have gone over to seams brazed with silver solder. Seams have failed due to galvanic attack and intergranular corrosion. Illustrations.—INCO.

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8.6 Group 6

8.6.3, 6.3.11
Platinum Metal Joints for Viscose Spinning. E. GRAFRIED, K. PROTZMANN, K. RUTHARDT, AND H. SPEIDEL. *Heraeus Festschrift*, 43-51 1951. *J. Inst. Metals & Metall. Abs.*, 19, Pt. 6, 480 1952 Feb.
A review of the study of design, composition and production of jets for the extrusion of spinning of viscose rayon. Jets made of platinum were too soft and liable to be worn by the viscose when the latter contained titanium dioxide. The alloys which were used for hardening are given. A 70:30 gold-platinum, sold under the trade name V73, is now used to make jets. Gold-platinum alloys containing 0.3-0.5 rhodium appear to have most of the desired properties for jet manufacture.—INCO.

8.7 Group 7

8.7.1, 5.9.4, 6.4.2
Prevention of Metal Plate Oxidation in Lithographic Platemaking. CHARLES W. LATHAN. *American Printer*, 133, 24-25, 50 + (1952) May.
Describes Cronak or Brunak treatment for metal lithographic plates. Prevents oxidation, simplifies platemaking, improves printing, produces sharper images, and improves grain characteristics.—BTR.

8.8 Group 8

8.8.1
Corrosion—And Its Control in a Chemical Plant. C. W. DAY (Celanese). Paper before NACE, South Central Reg., Oct. 18, 1951. *Chem. Eng.*, 59, No. 1, 155-157 (1952) Jan.
Program used by the Celanese Corp. at its Bishop, Tex., plant for combating corrosion. For field exposure, two types of test racks, one of which is furnished by Inco, are used. Pitting was found in gasketed joints in stainless piping and as a result, an evaluation program was conducted for various gasket materials. A water treating and inhibitor test program was also carried on in the metallurgical laboratory. Photographs of various types of corrosion of Type 316 stainless steels are shown.—INCO.

8.8.1, 7.4.2
Corrosion Problems in Processing. U. R. EVANS. *Can. Chem. Processing*, 36, 38, 40-41 (1952) Feb.
Discusses the main types of corrosion encountered in chemical industry, in connection with cooling systems.—BTR.

8.8.1, 7.6.1, 5.4.3, 6.6.6
Combat Corrosion with Glass-Lined Chemical Plant Equipment. Hungarian Heavy Industries. *Chem. Age*, 66, 455 (1952) Mar. 22.
An efficient and reliable solution of the corrosion problem has been reached in Hungary by development of a steel alloy (composition not given) ideally fusible with glass. Special welding electrodes and enamels with a suitable heat expansion coefficient have been found. Various glass-lined types of industrial chemical apparatus are described.—INCO.

8.8.3, 5.7.8
Additive Compounds in Electroplating

Baths. Part III. MARVIN RUBINSTEIN. *Metal Finishing*, 48, 68-74 (1950) Nov.

Describes mechanics of operation of wetting agents, addition salts, and sequestering agents.—RPI.

8.8.5, 3.7.3, 5.9.5
Induction Heat Cuts Descaling Costs. *Iron Age*, 169, 106 (1952) Jan. 17.

Method at Farmall Works of International Harvester whereby steel bars move automatically from furnace to inductor where heat rapidly expands scale which breaks off. The scale collects around left side of inductor and falls to receptacle. Water spray after quench aids operation.—MR.

8.8.5, 3.7.3, 5.9.5
Fast Economical Descaling by Use of Induction Heat. HOMER KINCAID. *Automotive Inds.*, 106, 43, 98 (1952) Jan. 15.

Results of the process for removal of surface scale from metal parts after heat treatment. Theory is discussed.—MR.

8.8.5, 6.3.6, 3.7.5
Plaster Mold Castings are Tougher and Smoother Than Sand Casting of the Same Alloy. T. H. KUMMER, Cherry-Burrell Corp. *Precision Metal Molding*, 10, No. 3, 27-30 (1952) Mar.

The Cherry-Burrell Corp., has converted from 22 nickel bearing copper alloy sand castings to fifteen nickel-brass plaster mold castings made by the Universal Castings Corp., Chicago for the packaging of fluid milk. These castings require less final machining, no surface polishing, simpler and less expensive jigs and fixtures and are resistant to wear by sliding friction. Holes, slots, recesses, and steel inserts are cast in. For stainless steel parts of irregular contour, investment castings are used. The inner valve rod plug, cast in 303 stainless steel just requires polishing. Elimination of porosity, machining, and polishing and special barrel technique are discussed. Illustrations.—INCO.

8.9 Group 9

8.9.5, 7.4.2, 4.6.4, 4.6.11
Corrosion and Related problems in Sea-Water Cooling and Pipe Systems in H. M. Ships. I. G. SLATER, L. KENWORTH, AND R. MAY. *J. Inst. Metals*, 77, Part 4, 309-330 (1950); *Corrosion*, 8, No. 12, 417-429 (1952) Dec.

A study is presented of corrosion and related problems that were encountered in sea-water cooling systems during war-time service. Details are given of the deterioration liable to occur in the component parts of the system, such as inlets, valves, gratings, pumps, trunking, condenser doors, tube-plates, ferrules, condenser tubes, and piping. Impingement attack and deposit attack were the two most prominent types of corrosion encountered. It is shown that the main factors which influence these are water speeds with related eddies and turbulence, entangled air bubbles, tube obstructions, and contamination of the water. Remedial and palliative measures are discussed in relation to the corrosion-resistance of the materials and protective coatings available; the use of different alloys in the same system; modifications of design for minimizing the severity of the conditions; and the importance of maintenance routines.

Laboratory tests, and especially the jet-impingement apparatus, are shown

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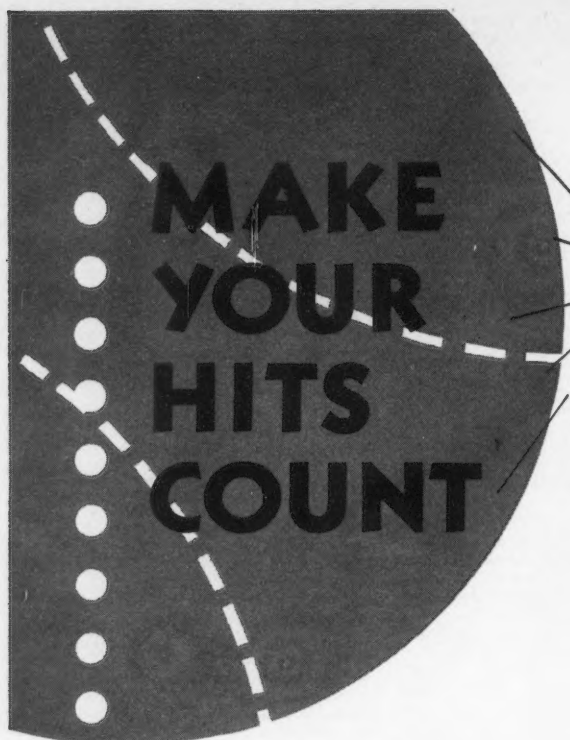
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to be of great value in indicating the probable service behavior of materials, provided certain precautions are observed.

8.10 Group 10

8.10.2, 1.2.3
Does New Process Challenge Foundries? L. FRAME. *Canadian Metals*, 15, No. 3, 28-29 (1952) Mar.

Walter H. Irwin with Canada Metal Co. has cracked the secret of the cored forging and pressing process which bridges the gap between sand and die casting. So far, production has been limited to brass and bronze but is expected to take in copper, aluminum and other metals. The secret of the process involves close metallurgical control—as close as required for steel when it is being heat treated, design of special press and design of dies. Applications and advantages are given. Illustrations.—INCO.



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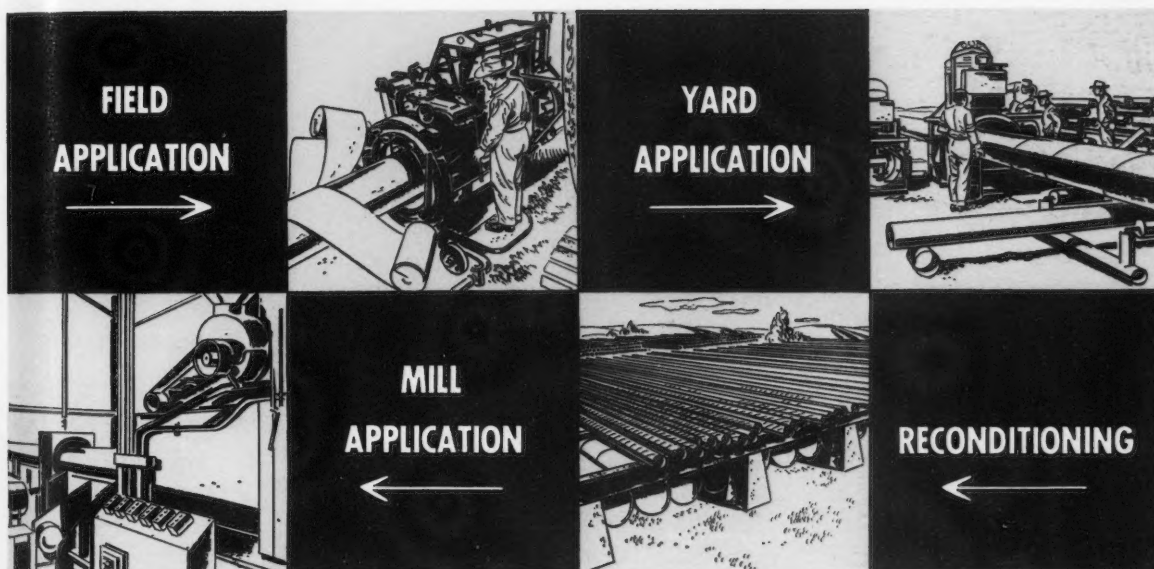
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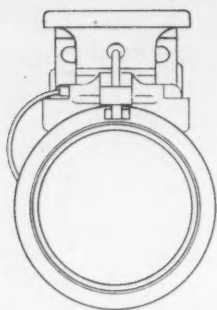
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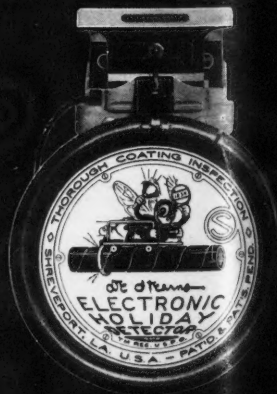
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